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RESPIRATORY CARE

A MONTHLY SCIENCE JOURNAL
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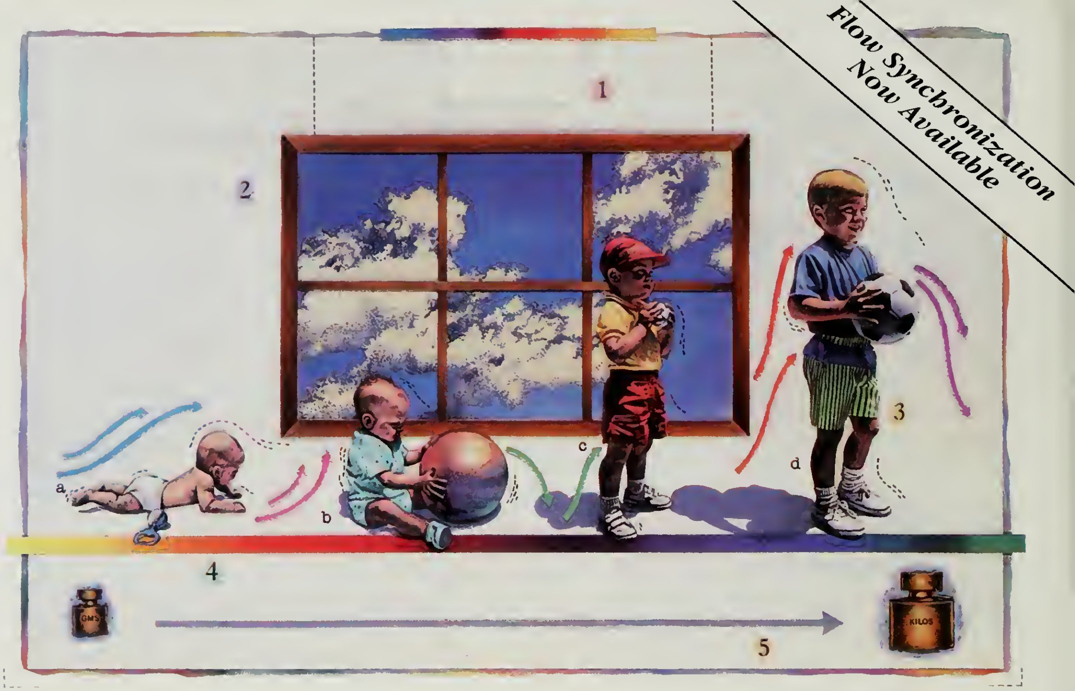

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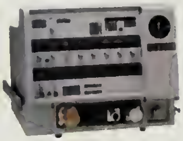

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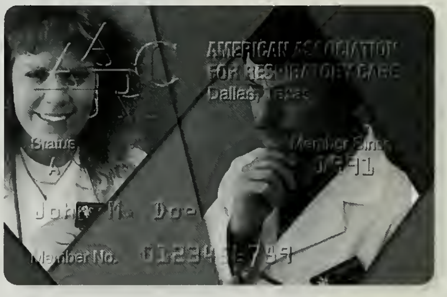

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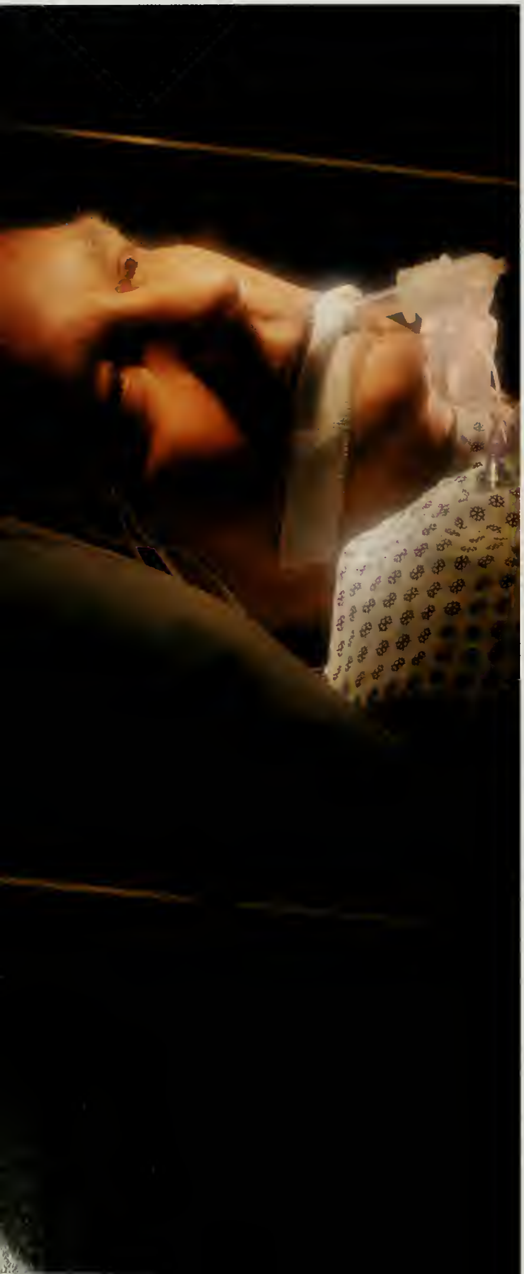

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The Common Cold (editorial)—AS Monto. JAMA 1994;271(14):1112. (Pertains to Forstall et al and Hendley et al papers abstracted on Page 691.)

Iatrogenous Pneumothorax (editorial)—R Berger. Chest 1994;105(4):980. (Pertains to Despars et al paper abstracted on Page 698.)

Blood Gas Monitors: Justifiable Enthusiasm with a Note of Caution (editorial)—BA Shapiro. Am J Respir Crit Care Med 1994;149:850.

Ribavirin in Severe Respiratory Syncytial Virus Infection—B Krafte-Jacobs. Crit Care Med 1994;22(4):541. (Pertains to Meert et al paper abstracted on Page 704.)

Ventilation of the Acute Respiratory Distress Syndrome: Looking for Mr Goodmode (editorial)—JJ Marini. Anesthesiology 1994;80(5):972. (Pertains to Lessard et al paper abstracted on Page 704.)

Influence of Head-Neck Posture on Airflow and Pulmonary Mechanics in Preterm Neonates—F Reiterer, S Abbasi, VK Bhutani. Pediatr Pulmonol 1994;17:149.

The influence of head-neck posture (neutral, 15°, 30°, and 45° extension and flexion) on airflow and pulmonary mechanics was evaluated in 10 spontaneously breathing healthy preterm neonates (mean ± SD; birthweight 1.32 ± 0.23 kg; gestational age 29.4 ± 2.4 weeks; study age 36.6 ± 1.6 weeks) who had had respiratory distress syndrome. Head-neck postures were quantified using specially constructed wooden wedges. Airflow was measured by a pneumotachometer via face mask. Lung compliance (C_L) and resistance (R_L) were measured using an esophageal balloon. Airflow interruption was designated as mild (10-40%), moderate (40-80%), and severe (> 80-100%) decrease of airflow. At neutral head-neck posture, 42.8 ± 7.5% SEM of breaths had airflow interruption (71.4% mild, 19.9% moderate, 8.7% severe). There was no significant change with 15° and 30° head-neck flexion and extension. However, at 45° flexion the overall incidence of airflow interruption (77.3 ± 4.8%, $p < 0.05$) and R_L (86.6 ± 6.7 vs 64.2 ± 3.9 cm $H_2O/L/s$, mean ± SEM; $p < 0.05$) significantly increased. Extension to 45° caused severe airflow interruption and increased R_L in some infants, but no statistically significant change for the whole group. The incidence of severe airflow interruption significantly increased ($p < 0.05$) from 8.7% at neutral head-neck posture to 26.3% at hyperflexion (45°). No changes in C_L were observed. We conclude that minor (15-30°) deviations from neutral neck posture are insignificant, whereas hyperflexion, and in some infants, hyperextension, can significantly affect airflow and pulmonary mechanics.

Components of the Work of Breathing and Implications for Monitoring Ventilator-Dependent Patients—MJ Banner, MJ Jaeger, RR Kirby. Crit Care Med 1994;22(3):515.

OBJECTIVES: (a) To discuss the components of the work of breathing using an established physiologic model (Campbell diagram); (b) to describe the requirements of a monitor to measure work; and (c) to discuss the implications and relevance for assessing the work of breathing of ventilator-dependent patients. DATA SOURCES: Relevant articles from the medical and physiologic literature are referenced, as well as the authors' experience. STUDY SELECTION: Identified (by authors) laboratory and clinical research establishing the need and physiologic importance for correctly measuring the work of breathing. DATA EXTRACTION: A physiologic model of the various components of the work of breathing is used in conjunction with data from published literature. SYNTHESIS: Diagrams of increasing complexity based on the Campbell diagram depict the physiologic elastic and resistive work of breathing for the lungs and chest wall under normal and abnormal conditions. Decreases in compliance and increases in airways resistance are associated with increases in elastic and resistive work, respectively. A modification of the Campbell diagram to include an additional area depicting the imposed work of the breathing apparatus is suggested (ie, the additional resistive load imposed on the respiratory muscles by the endotracheal tube, breathing circuit, and the ventilator's demand-flow system during spontaneous breathing). Increases in physiologic and/or imposed work result in respiratory muscle loading, predisposing to increases in oxygen consumption and the development of fatigue and hypercapnia. Measuring work of breathing by integrating the area of the esophageal pressure-volume loop alone underestimates the work of breathing relative to the Campbell diagram and, therefore, should not be used. Because the site of pressure measurement and mode of ventilation influence measurements of the work of breathing as well as compliance, clinicians should be aware of these factors when interpreting measurements. Monitors that are used in clinical practice to assess the work of breathing should be able to measure pressure at the airway opening (between the Y-piece of the breathing circuit and the endotracheal tube), at the carinal end of the endotracheal tube, and in the esophagus (inference of intrapleural pressure); as well as measure flowrate and volume at the airway opening; and calculate the various components of the work of breathing based on the Campbell diagram. CONCLUSIONS: Accurate measurement of physiologic and imposed work performed by the patient is essential to assess the afterload on the respiratory muscles, diagnose specific work of breathing abnormalities, and monitor the effects of interventions to mitigate respiratory muscle loading. Work of breathing data are useful in formulating objective guidelines for setting the ventilator appropriately to optimize respiratory muscle loads (eg, selecting an appropriate amount of pressure support ventilation to decrease the work of breathing to a specific level).

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[1] M.K. Reeves-Hoche', et al, CPAP vs BiPAP· Patient Compliance in the Treatment of Obstructive Sleep Apnea, Six Month Data in a Two-Year Study. Presented at ALA/ATS 1993 Study funded by Respironics. [2] $p = .09$ [3] $p \leq .001$

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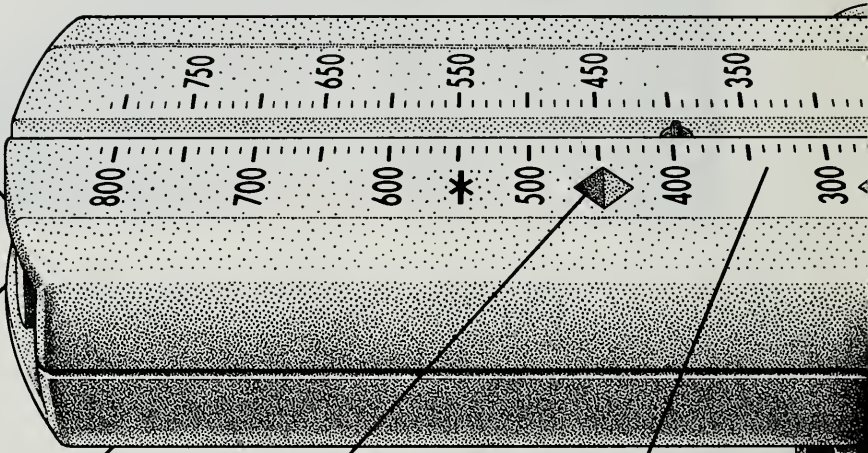

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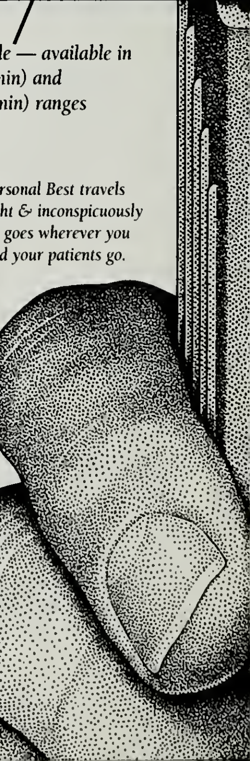

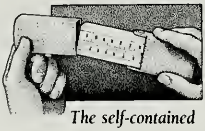

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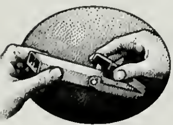

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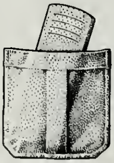

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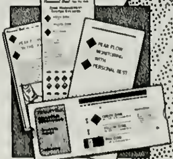

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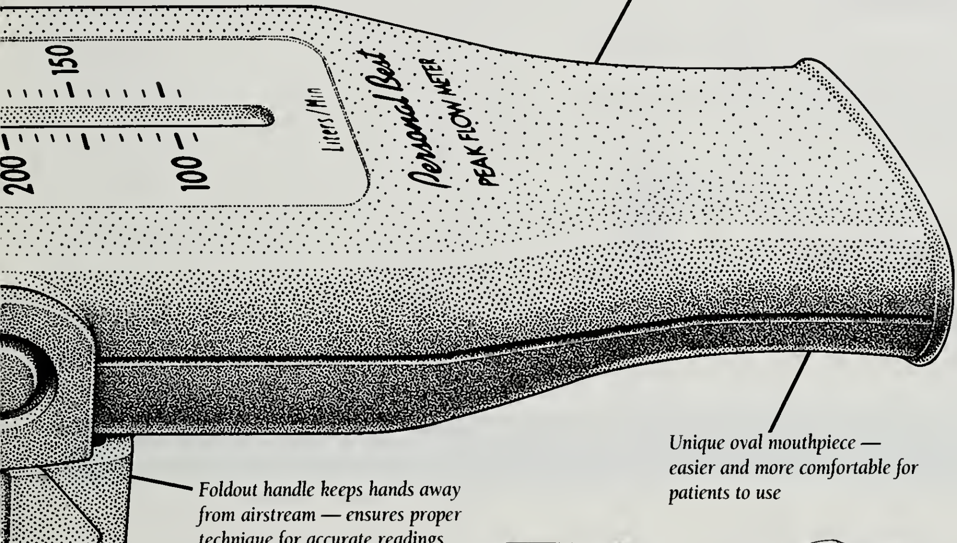

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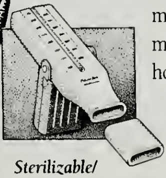

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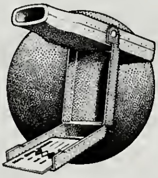

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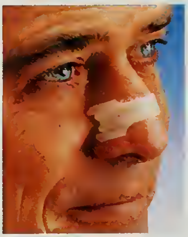

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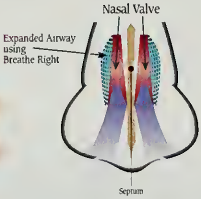

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Variations in Flows and Pressures during Jet Ventilation in the Infant: A Model Study—A Belaguid, H Guenard. Pediatr Pulmonol 1994;17:183.

Ventilatory flowrates with either He-O_2 (heliox) or N_2-O_2 (nitrox) mixtures during high frequency jet ventilation (HFJV) were calculated using a mathematical model, and were measured in a physical monoalveolar model of the infant lung. A constant flow was delivered to the model ($\dot{V}_d$) drawing with it an entrained flow ($\dot{V}_e$). When the inspiratory time (t_i) was long, a back flow ($\dot{V}_r$) was generated that increased progressively as the alveolar pressure increased. In order to reduce $\dot{V}_r$, the reflux time (t_r), ie, the time needed for the injected gas to reflux, was measured (t_{rm}) and calculated (t_{rc}) with the model. The t_r depends on both chest-lung compliance and resistance to reflux as well as on the $\dot{V}_e/\dot{V}_d$ ratio. For a given setting of the ventilator, values of t_{rm} and t_{rc} were significantly lower with heliox than nitrox ($p < 0.01$), and the correlation between t_{rm} and t_{rc} were fair with both gases. Tidal volume (V_T) was calculated when the t_i was interrupted at t_r. The values of V_T were significantly higher with heliox than nitrox ($p < 0.05$). It is concluded that the evaluation of t_r during HFJV may provide useful information for setting the ventilator.

Magnetic Resonance Imaging of the Heart during Positive End-Expiratory Pressure Ventilation in Normal Subjects—C Leithner, A Podolsky, S Globits, H Frank, A Neuhold, J Pidlich, et al. Crit Care Med 1994;22:426.

OBJECTIVES: Magnetic resonance imaging was used to assess the effects of ventilation with positive end-expiratory pressure (PEEP) on cardiac volumes, especially on atrial volumes as well as to determine semiquantitative measurements of spatial interactions between heart, lungs and chest. DESIGN: Prospective study with healthy volunteers undergoing mechanical ventilation with different levels of PEEP during magnetic resonance imaging. SETTING: Magnetic resonance unit, Institute of Diagnostic Imaging, Rudolfinerhaus Hospital. SUBJECTS: 12 healthy volunteers. INTERVENTIONS: Volunteers were imaged, using a multislice-multiphase technique during spontaneous breathing and with PEEP values of 0, 7, and 15 cm H_2O. MEASUREMENTS & MAIN RESULTS: Atrial as well as ventricular volumes, chest diameters, and midventricular contact between the heart and anterior chest wall were determined on transverse-oblique sections. Atrial volumes showed a progressive decline beginning at a PEEP of 7 cm H_2O. Diastolic filling of both ventricles was reduced. A PEEP level of 15 cm H_2O induced a significant increase in the sagittal-oblique but not in the transverse-oblique chest diameter. PEEP values of 7 and 15 cm H_2O shortened the length of the midventricular contact between the heart and anterior chest wall. CONCLUSIONS: Left and right ventricular end-diastolic volumes and stroke volumes decreased significantly during ventilation with PEEP at 15 cm H_2O, as did end-systolic atrial volumes. Volume changes in association with changes of chest and heart configuration suggest external cardiac compression by the expanding lungs. Furthermore, this study illustrates the feasibility of magnetic resonance imaging in mechanically ventilated patients.

Continuous Measurement of Energy Expenditure in Ventilated Burn Patients: An Analysis—D Royall, L Fairholm, WJ Peters, KN Jeejeebhoy, JP Allard. Crit Care Med 1994;22:399.

OBJECTIVE: To predict the daily total energy expenditure of ventilated burn patients, this study was designed to determine the contribution of different activities on energy expenditure over a 24-hr period. DESIGN: Cohort study. SETTING: Burn unit of an adult hospital. PATIENTS: 20 clinically stable burn patients undergoing mechanical ventilation with 36.7 ± 4.2 total % burn surface area. INTERVENTIONS: Patients were fed according to a previously validated equation which takes into account the Harris-Benedict equation, % burn surface area, caloric intake, body temperature, and the number of postburn days: Toronto Formula = –4,343 + (10.5 × % burn surface area) + (0.23 × caloric intake) + (0.84 × Harris-Benedict equation) + (114 × body temperature) – (4.5 × postburn days). The total energy expenditure of patients was measured by indirect calorimetry and their activity levels were recorded over a 24-hr period. RESULTS: The calculated Toronto Formula was 2,191 ± 83 kcal/day, and patients were fed 2,276 ± 40 kcal/day. The measured resting energy expenditure was 2,149 ± 102 kcal/day and was similar to the Toronto Formula (NS). The total energy expenditure was 2,492 ± 120 kcal/day. Altogether the activities contributed 27.3 ± 1.3% to the total energy expenditure and did not correlate with the % burn surface area. The activity factor calculated as [total energy expenditure less resting energy expenditure] × 100/resting energy expenditure was 16.6 ± 2.4% and calculated as [total energy expenditure less Toronto Formula]/Toronto Formula was 14.5 ± 4.3%. CONCLUSIONS: These results suggest that in clinically stable, mechanically ventilated burn patients, the Toronto Formula accurately predicts the resting energy expenditure and that the Toronto Formula or the resting energy expenditure × 1.2 can be used to estimate the total daily energy requirements.

Effect of Inhaling Heated Vapor on Symptoms of the Common Cold—GJ Forstall, ML Macknin, BR Yen-Lieberman, SV Medendorp. JAMA 1994;271(14):1109.

OBJECTIVE: To test the efficacy of steam inhalation in treating common cold symptoms. DESIGN: An in-vitro study determined the temperature that inactivated rhinovirus: a temperature of 43°C lasting at least 1 hour was needed. We then conducted a double-blind, placebo-controlled, randomized in-vivo study. SETTING: The virology laboratory and the outpatient department of the Cleveland (Ohio) Clinic Foundation. PATIENTS: 68 Cleveland Clinic employee volunteers with symptoms of the common cold at the time of enrollment. INTERVENTION: A single 60-minute treatment was given to the volunteers. The steam treatment group ($n = 32$) received 40 L/min of heated saturated air that raised the intranasal temperature to 43°C. The placebo group ($n = 36$) received 2 L/min of ambient air at 20°C to 24°C. MAIN OUTCOME MEASURES: Subjective symptom scores for nasal congestion, nasal drainage, and sneezing and objective measures of nasal resistance were studied during a 7-day follow-up observation period. RESULTS: There were no significant differences in daily symptom scores between the groups ($p = 0.59$ to 0.83). The only statistically significant differences between the groups were lower nasal resistances at baseline in the steam group ($p = 0.04$) and percent improvement in nasal resistance favoring the placebo group on Day 7 ($p = 0.01$). However, these differences were of questionable clinical significance. CONCLUSION: We conclude that steam inhalation treatment had no beneficial effect on the cold symptoms of our volunteers.

Effect of Inhalation of Hot Humidified Air on Experimental Rhinovirus Infection—JO Hendley, RD Abbott, PP Beasley, JM Gwaltney Jr. JAMA 1994;271(14):1112.

OBJECTIVE: Nasal inhalation of steam has been proposed as treatment of viral colds on the assumption that increased intranasal temperature will inhibit replication of rhinovirus (RV). The effect of steam inhalation on RV shedding by infected volunteers was examined in this study. DESIGN: Randomized controlled trial. Volunteers experimentally infected with RV were treated with machine-generated humidified air, which was either hot (active) or at room temperature (placebo). Viral shedding was assessed over the 4 days following treatment. SETTING: Local hotel. PARTICIPANTS: 20 volunteers from the universi-

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ty community who were susceptible to the challenge virus. INTERVENTION: Two 30-minute intranasal treatments, the first at 24 hours after inoculation and the second at 48 hours. The temperature of active vapor was 42°C to 44°C and of placebo vapor was 22°C. MAIN OUTCOME MEASURES: Viral titers in nasal washings on each of 5 days following inoculation. RESULTS: Mean viral titers prior to the first treatment were $10^{1.7}$ tissue culture infectious doses$_{50}$ per milliliter in the active group and $10^{1.5}$ in the placebo group. Mean titers for the next 4 days were $10^{1.7}$, $10^{1.7}$, $10^{1.2}$, and $10^{0.9}$/mL in the active group and $10^{1.8}$, $10^{1.9}$, $10^{1.6}$, and $10^{0.7}$/mL in the placebo group (no significant difference). The proportion of volunteers who shed virus on each day was also similar in the two groups. CONCLUSION: Two nasal inhalation treatments with steam had no effect on viral shedding in volunteers with experimental RV colds.

Understanding and Using the Medical Subject Headings (MeSH) Vocabulary To Perform Literature Searches—HJ Lowe, GO Barnett. JAMA 1994;271(14):1103.

The United States National Library of Medicine's (NLM) MEDLINE database is the largest and most widely used medical bibliographic database. MEDLINE is manually indexed with NLM's Medical Subject Headings (MeSH) vocabulary. Using MeSH, a searcher can potentially create powerful and unambiguous MEDLINE queries. This article reviews the structure and use of MeSH, directed toward the nonexpert, and outlines how MeSH may help resolve a number of common difficulties encountered when searching MEDLINE. The increasing importance of the MEDLINE database as an information resource and the trend toward individuals performing their own bibliographic searches makes it crucial that health-care professionals become familiar with MeSH.

Feasibility of Continuous Oxygen Delivery and Cardiac Output Measurement by Application of the Fick Principle—PJ Feustel, RJ Perkins, JE Oppenlander, HH Stratton, IL Cohen. Am J Respir Crit Care Med 1994; 149:751.

Continuous mixed venous oxygen saturation ($S_{\bar{v}O_2}$) measurements from fiberoptic pulmonary artery catheters, arterial oxygen saturation (S_{aO_2}) measurements from pulse oximetry, and minute-by-minute oxygen consumption ($\dot{V}_{O_2}$) measurements from indirect calorimetry can be used for near-continuous estimation of cardiac output ($\dot{Q}_t$) and oxygen delivery ($\dot{D}_{O_2}$) by application of the Fick Principle. Assumptions required for calculation of blood oxygen contents include constant hemoglobin concentration (Hgb) and constant or negligible physically dissolved oxygen. First, the influence of these assumptions on continuous $\dot{Q}_t$ and $\dot{D}_{O_2}$ determinations was tested. Unmeasured changes in Hgb resulted in substantial error in calculated $\dot{Q}_t$, whereas calculated $\dot{D}_{O_2}$ was minimally affected. Both ($\dot{Q}_t$ and $\dot{D}_{O_2}$ were little altered by errors in P_{aO_2} or $P_{\bar{v}O_2}$. Second, the effects of $S_{\bar{v}O_2}$, S_{aO_2}, and $\dot{V}_{O_2}$ measurement errors on $\dot{Q}_t$ and $\dot{D}_{O_2}$ calculations under normal and extreme conditions were quantified. Relative errors in $S_{\bar{v}O_2}$ were increased by a factor of 4.2 in $\dot{Q}_t$ estimations and by a factor of 3.2 in $\dot{D}_{O_2}$ measurements under normal conditions. These factors increased with increasing $S_{\bar{v}O_2}$, and, thus, $\dot{Q}_t$ and $\dot{D}_{O_2}$ became increasingly unreliable as oxygen extraction fell. Third, we compared continuous measurements of $\dot{Q}_t$ and $\dot{D}_{O_2}$ with intermittent measurements made by thermodilution cardiac output and blood sampling, and found correlation coefficients of 0.85 for $\dot{Q}_t$ and 0.89 for $\dot{D}_{O_2}$. Fourth, common measurement errors in $\dot{V}_{O_2}$ and $\dot{D}_{O_2}$ calculated in this way were found to bias regressions between $\dot{V}_{O_2}$ and $\dot{D}_{O_2}$, and this bias could be minimized only if the $\dot{D}_{O_2}$ range were high and $S_{\bar{v}O_2}$ were low. With attention paid to these problems, continuously measured $\dot{Q}_t$ and $\dot{D}_{O_2}$ may be usefully applied for the assessment of $\dot{D}_{O_2}$-dependent $\dot{V}_{O_2}$ within a single patient.

Gender Differences in Sleep Disordered Breathing in a Community-Based Sample—S Redline, K Kump, PV Tishler, I Browner, V Ferrette. Am J Respir Crit Care Med 1994; 149:722.

Gender differences in the relative frequency of sleep-disordered breathing (SDB) have been observed in surveys of patient groups referred for clinical evaluation compared with population surveys. In this study, we assessed the associations of gender, SDB, and symptoms of SDB in 389 participants (16 to 84 yr of age) in an ongoing genetic-epidemiologic study of sleep apnea. Subjects included index probands with laboratory-confirmed obstructive sleep apnea syndrome (laboratory sample, n = 36) and their family members and neighbors (the community sample). SDB was assessed with overnight in-home monitoring of airflow, oximetry, heart rate, and chest wall impedance, and symptoms were assessed with standardized questionnaires. In the entire sample, SDB, defined as a respiratory disturbance index [RDI] ≥ 15, was more prevalent among males (38%) than among females (15%) ($p < 0.05$). Males predominated by a ratio of 8:1 in the laboratory sample (31 males, 5 females). In contrast, the proportion of males to females with SDB was only 2:1 in the community sample, in which an RDI ≥ 15 was observed among 26% of males and 13% of females. In the laboratory sample, females tended to be younger and were significantly heavier than males. However, in the community sample, females with SDB were older than male apneic subjects (63.4 ± 13.9 vs 47.2 ± 15.6 years, mean ± SD; $p < 0.01$), and included a majority of postmenopausal women (75%). No differences in body mass index were noted between males and females with SDB recruited from the community. Compared with males, females consistently underreported symptoms of snoring, snorting, gasping, and apnea. After adjusting for RDI, women were 2 to 3 times less likely than males to report these symptoms. We conclude that SDB is common in older females, and occurs frequently in the absence of morbid obesity. SDB may be recognized less frequently clinically in females, in part because of underreporting of symptoms of disturbed breathing during sleep.

Ventilatory Responses during Wakefulness in Children with Obstructive Sleep Apnea—CL Marcus, D Gozal, R Arens, DJ Basinski, KJ Omlin, TG Keens, SLD Ward. Am J Respir Crit Care Med 1994;149:715.

The pathophysiology of the obstructive sleep apnea syndrome (OSAS) is not fully understood. In children, airway obstruction secondary to tonsilloadenoidal hypertrophy is the leading cause of OSAS. However, not all children with tonsilloadenoidal hypertrophy develop OSAS. Thus, other factors, including abnormalities in ventilatory control, may contribute to the etiology of OSAS. To test this, we performed polysomnography and hypercapnic and hypoxic ventilatory response testing in 20 children and adolescents with OSAS (mean age, 8 ± 3 [SD] yr) and 19 control subjects. Only two children with OSAS were obese. Children with OSAS had an apnea index of 16 ± 20, peak P_{etCO_2} of 54 ± 5 mm Hg, and S_{aO_2} nadir of 84 ± 13% during polysomnography. Ventilatory responses were performed by rebreathing techniques. The slope of the hypercapnic ventilatory responses, corrected for body surface area, was 1.74 ± 0.79 L/min/m²/mm Hg P_{etCO_2} in children with OSAS and 1.45 ± 0.58 L/min/m²/mm Hg P_{etCO_2} in control subjects (NS). Hypoxic ventilatory responses, corrected for body surface area, were −0.94 ± 0.49 L/min/m²/% S_{aO_2} in children with OSAS and −0.95 ± 0.45 L/min/m²/% S_{aO_2} in control subjects (NS); however, the sample size was small. There was a weak inverse correlation between the slope of the hypercapnic ventilatory response and the duration of hypoventilation during polysomnography ($r = -0.44$, $p < 0.05$). We conclude that children with OSAS have normal ventilatory responses to hypercapnia, and they may have normal ventilatory respons-

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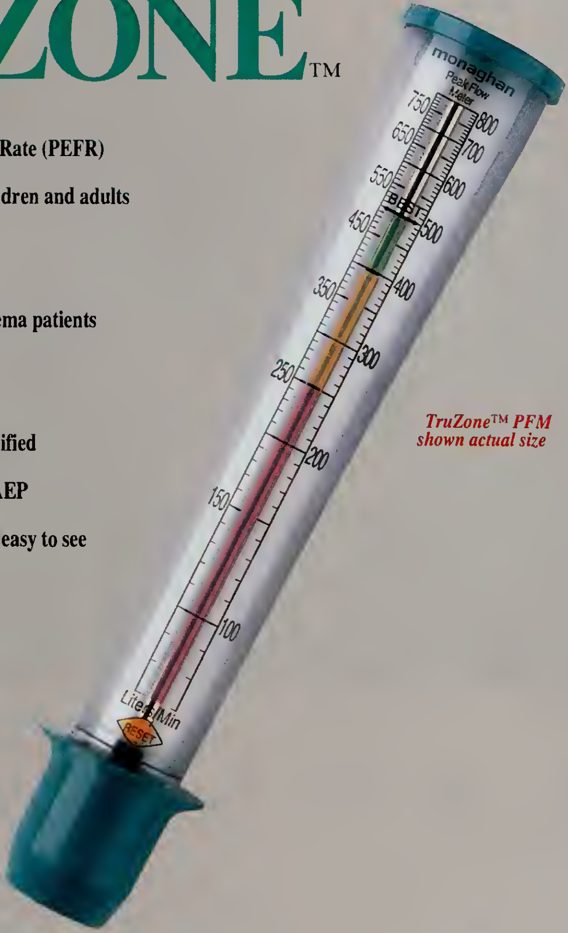

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es to hypoxia. We speculate that abnormal central ventilatory drive plays little if any role in the pathogenesis of pediatric OSAS. Furthermore, we speculate that the diminished ventilatory responses seen in adults with OSAS are acquired secondary to chronic hypoxemia and hypercapnia.

A Cohort Analysis of Excess Mortality in Asthma and the Use of Inhaled β-Agonists—S Suissa, P Ernst, J-F Boivin, RI Horwitz, B Habbick, D Cockroft, et al. Am J Respir Crit Care Med 1994;149:604.

The association between the use of inhaled β-agonists and the risk of death and near-death from asthma has previously been reported. It was based on a nested case-control study of 129 cases and 655 control subjects selected from a cohort of 12,301 users of asthma drugs followed during the period 1980 through 1987. In this paper we examine the question of asthma and non-asthma mortality using data from the entire cohort of 12,301 asthmatics. There were 46 asthma and 134 non-asthma deaths in this cohort, for which there were 47,842 person-years of follow-up. The overall rate of asthma death was 9.6 per 10,000 asthmatics per year. This rate varied significantly according to the use of fenoterol, albuterol, or oral corticosteroids in the prior 12 months and the number of asthma hospitalizations in the prior 2 years. The rate decreased significantly, by 0.6 asthma deaths per 10,000 asthmatics per year over the study period, after controlling for the effect of the four other risk factors. It also increased significantly with the use of all β-agonists, and more so for fenoterol than for albuterol, although this difference was partly explained by the dose inequivalence of the two drugs. Change-point dose-response curves showed that the risk of asthma death began to escalate drastically at about 1.4 canisters (of 20,000 μg each) per month of inhaled β-agonist, the recommended limit. For non-asthma death, the overall rate of 28 deaths per 10,000 asthmatics per year was not related to the use of inhaled β-agonists. We conclude that the strong association between the use of inhaled β-agonists and asthma mortality is confined primarily to the use of these drugs in excess of recommended limits. Non-asthma mortality, including that from cardiovascular causes, is not associated with the use of inhaled β-agonists.

Longitudinal Analysis of the Effects of Smoking Onset and Cessation on Pulmonary Function—DL Sherrill, CJ Holberg, PL Enright, MD Lebowitz, B Burrows. Am J Respir Crit Care Med 1994;149:591.

We examined the effects of smoking onset and cessation on FEV_1 in participants in the Tucson Epidemiological Study of Airways Obstructive Disease 18 yr of age or older who reported a change in smoking habits during 17 yr of follow-up. Subjects were classified as "new quitters" (n = 288) and "new starters" (n = 45) at each survey on the basis of questionnaire responses concerning current smoking habits. The pulmonary function data were analyzed using a mixed longitudinal or random effects model (REM). We compared FEV_1 before and after changing smoking habits in the same subjects while adjusting for important covariables such as height, pack-years, and respiratory symptoms and diseases. The results for smoking cessation showed a beneficial effect related to quitting that was largest for younger subjects and decreased linearly with age. For women, quitting resulted in an improvement in FEV_1 of 4.3% at 20 yr of age which decreased to 2.5% by 80 yr of age. Men had an improvement of only 1.2% at 20 yr of age and no improvement at 80 yr of age. After excluding subjects with low initial function (FEV_1/FVC in the lowest quartile) and those with only a single observation after quitting, men (n = 70) showed a significantly higher FEV_1 improvement of 4% at 20 yr of age that decreased linearly to zero by age 80 yr. In contrast, women in this subgroup (n = 89) had nearly the same degree of improvement at all ages. The onset results showed mean FEV_1 values after starting smoking that were higher at the younger ages (< 23 yr) and that decreased more rapidly with age, compared with nonsmoking mean estimates, in both sexes.

Effect of Continuous Positive Airway Pressure Treatment on Daytime Function in Sleep Apnoea/Hypopnoea Syndrome—HM Engleman, SE Martin, IJ Deary, NJ Douglas. Lancet 1994;343:572.

Continuous positive airway pressure (CPAP) is the treatment of choice for the sleep apnoea/hypopnoea syndrome (SAHS); it is usually given with the aim of improving daytime cognitive function, mood, and sleepiness. However, its efficacy has not been validated by controlled trials. We have carried out a randomised, placebo-controlled, crossover study of objective daytime sleepiness, symptoms, cognitive function, and mood in a consecutive series of 32 SAHS patients with a median apnoea plus hypopnoea frequency of 28 (range 7-129) per hour slept. Patients were treated with 4 weeks each of CPAP and an oral placebo, which they were told might improve upper airway muscle function during sleep. Assessments on the last day of each treatment included a multiple sleep latency test and tests of symptom scores, mood profiles, and cognitive performance. The patients had significantly less daytime sleepiness on CPAP than during the placebo period (mean sleep latency 7.2 [SE 0.7] vs 6.1 [0.7] min, p = 0.03). There were also improvements with CPAP in symptom ratings (2.1 [0.2] vs 4.3 [0.3], p < 0.001), mood (p < 0.05 for several measures), and cognitive performance, which showed improved vigilance (obstacles hit in Steer Clear "driving" test 76 [5] vs 81 [6], p < 0.01), mental flexibility (trailmaking B time 66 [5] vs 75 [5] seconds, p < 0.05), and attention (p < 0.05). Objectively monitored CPAP use averaged only 3.4 (0.4) hours per night, but this study provides evidence of improved cognitive performance even at this low level of CPAP compliance.

Postdischarge Survival and Functional Status following In-Hospital Cardiopulmonary Resuscitation—GR Robinson, D Hess. Chest 1994;105(4):991.

Outcome from cardiopulmonary resuscitation (CPR) at community hospitals is seldom reported in the literature. Data regarding long-term functional status of CPR survivors are virtually nonexistent. We retrospectively reviewed the medical records of all patients receiving CPR during 1989 at a community teaching hospital to determine survival to hospital discharge from CPR. Long-term functional status was determined by contacting primary care physicians in January 1992. We found 24 of 83 (29% percent) patients survived in-hospital CPR and were discharged. Follow-up of these 24 patients showed 13 (54%) were alive a mean of 31 months postdischarge with 10 of the 13 (77%) reported to be living independently. We believe survival from CPR at community teaching hospitals is comparable to university hospitals. Additionally, patients who survive in-hospital CPR to hospital discharge have a 54% chance of being alive a mean of 31 months postdischarge with most being able to live independently. Further work is needed to validate these long-term functional status results.

A 1-Week Dose-Ranging Study of Inhaled Salmeterol in Patients with Asthma—EA Bronsky, JP Kemp, HA Orgel, CW Bierman, DG Tinkelman, A van As, RF Liddle. Chest 1994;105(4):1032.

STUDY OBJECTIVE: A dose-ranging study was conducted to evaluate the efficacy and safety of a new long-acting, selective β_2-adrenoceptor agonist, salmeterol. DESIGN: Adolescents and adults (n = 160) with mild-to-moderate asthma received salmeterol (10.5, 21, 42, or 84 μg) or placebo by metered-dose inhaler twice daily for 1 week. Twelve-hour serial spirometry measurements were performed on the first and last days of treatment, and patients recorded their peak expiratory

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flow (PEF) twice daily on diary cards. RESULTS: On Day 1, salmeterol produced greater bronchodilation than placebo ($p = 0.001$), and both the 42-μg and 84-μg doses of salmeterol were significantly more effective in improving FEV_1 responses than the two lower doses of salmeterol ($p < 0.05$). After 1 week of treatment, all but the 21-μg dose of salmeterol remained statistically superior to placebo ($p < 0.01$), but significant differences between salmeterol doses were no longer evident, despite an apparent dose-response effect. Only the 42-μg and 84-μg doses of salmeterol sustained bronchodilation for 12 hours in the majority of patients at both treatment days. The degree of improvement in morning and evening PEF was also found to be dose related. There was no significant difference among treatment groups in the overall incidence of adverse events; however, pharmacologically predictable events (eg, tremor) occurred significantly more often with salmeterol, 84 μg. CONCLUSIONS: Salmeterol, 42 μg, was similar in efficacy to 84 μg but was associated with a lower incidence of adverse events. Salmeterol, 42 μg twice daily, is a safe and effective dosage for patients with mild-to-moderate asthma who are persistently symptomatic and require maintenance bronchodilator therapy.

Respiratory Muscle Rest Using Nasal BiPAP Ventilation in Patients with Stable Severe COPD—JP Renston, AF DiMarco, GS Supinski. Chest 1994;105(4):1053.

To more systematically evaluate the effect of respiratory muscle rest on indices of ventilatory function, nine outpatients with stable, severe COPD were treated with nasal pressure-support ventilation delivered via a nasal ventilatory support system (BiPAP, Respironics Inc) for 2 h a day for 5 consecutive days. An additional eight control patients were treated with sham-BiPAP. Maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP), maximum voluntary ventilation (MVV), arterial blood gas values, Borg dyspnea score, dyspnea-associated functional impairment scales, and distance walked in 6 min were measured in subjects prior to and following the week-long trial. Nasal BiPAP produced a 66.3 ± 6 percent reduction in peak integrated diaphragmatic electromyographic (EMG) activity. There were no statistically significant changes in MIP, MEP, MVV, arterial pH, P_{aCO_2}, or P_{aO_2} or in objective measures of functional impairment from dyspnea in either group after ventilator or sham treatment. However, nasal BiPAP reduced the Borg category score during resting, spontaneous breathing from 2.0 ± 0.4 to 0.7 ± 0.3 ($p < 0.01$) after 5 days of treatment. In contrast, sham BiPAP-treated patients had no change in their dyspnea score, which was 1.8 ± 0.4 and 1.3 ± 0.4 before and after sham treatment, respectively. Nasal BiPAP also increased distance walked in 6 min from 780 ± 155 to 888 ± 151 ft ($p < 0.01$) (23,400 ± 4,650 to 26,640 ± 4,530 cm) ($p < 0.01$), whereas sham-BiPAP had no effect (768 ± 96 and 762 ± 106 ft [23,040 ± 2,880 and 22,860 ± 3,180 cm] before and after sham treatment, respectively). In conclusion, these results indicate that nasal pressure-support ventilation, delivered via nasal BiPAP, improves exercise capacity and reduces dyspnea over the short term in selected outpatients with stable severe COPD. Whether such short-term improvement can be sustained merits further study.

Effect of Low Flow and High Flow Oxygen Delivery on Exercise Tolerance and Sensation of Dyspnea: A Study Comparing the Transtracheal Catheter and Nasal Prongs—NA Dewan, CW Bell. Chest 1994;105(4):1061.

We hypothesized that high flow transtracheal oxygen (HFTTO) will improve exercise tolerance as compared with low flow transtracheal oxygen (LFTTO) and that transtracheal oxygen (TTO) will increase exercise tolerance with less dyspnea as compared with nasal prongs (NP) at equivalent oxygen saturation (S_{aO_2}). PATIENT SELECTION: 10 subjects, 6 male and 4 female, who were already receiving TTO were recruited for the study. STUDY DESIGN: Each subject underwent a total of four modified progressive treadmill tests in a single-blind randomized fashion on two separate days. Two tests were performed with the patients receiving LFTTO and HFTTO while the other two were performed with low- and high-flow oxygen by NP. The flows were adjusted to provide equivalent oxygen saturations at rest for respective groups. RESULTS: The mean ± SD exercise distance with HFTTO (1,134 ± 631 ft) was 2.5 times greater than with LFTTO (446 ± 328 ft; $p < 0.006$); and high-flow NP (HFNP [1207 ± 763 ft]) was 2.38 times greater than with low-flow NP (LFNP [492 ± 487 ft; $p < 0.005$]). There was no significant difference in exercise distance and dyspnea scores with HFTTO as compared with HFNP and LFTTO versus LFNP. CONCLUSION: We conclude that the use of high-flow oxygen via both transtracheal catheter and NP significantly increased exercise tolerance in our COPD patients when compared to low-flow oxygen. Transtracheal oxygen did not increase maximum exercise tolerance with less dyspnea as compared with oxygen via NP at equivalent S_{aO_2}.

Significance of Iatrogenic Pneumothoraces—JA Despars, CSH Sassoon, RW Light. Chest 1994;105(4):1147.

The purpose of this study was to review the cases of iatrogenic pneumothorax that occurred between October 1983 and December 1988 at the Veterans Administration Medical Center, Long Beach, California, to determine the treatment and complications. During this time period, 106 patients were identified with iatrogenic pneumothorax, and the charts of 98 were available for review. There were 90 cases of spontaneous pneumothorax at this institution during the same time period. The most common cause of iatrogenic pneumothorax was transthoracic needle aspiration (35), followed by thoracentesis (30), subclavian venipuncture (23), and positive pressure ventilation (7). In 11 cases, the cause was due to miscellaneous triggers. The majority of the patients (65 of 98) were treated with chest tubes. The chest tubes were in place 4.7 ± 3.9 days. Nine of the patients required a second chest tube. Aspiration of the pneumothorax only was attempted in 5 patients, and all patients subsequently received a chest tube. Two patients died from iatrogenic pneumothorax. One patient receiving positive pressure ventilation developed an unrecognized tension pneumothorax. The other patient developed a pneumothorax after thoracentesis and was treated with a chest tube, which led to a staphylococcal empyema and death. From this study, we conclude that the incidence of iatrogenic pneumothorax exceeds that of spontaneous pneumothorax and that there is substantial morbidity and some mortality from iatrogenic pneumothorax.

Anxiety and Depression in Relation to Respiratory Symptoms and Asthma—C Janson, E Björnsson, J Hetta, G Boman. Am J Respir Crit Care Med 1994;149:930.

The aim of this investigation was to study the relationship between psychologic status and respiratory health. The study comprised 715 persons aged 22 to 44 who participated in the European Commission Respiratory Health Survey. The study included a structured interview, spirometry, methacholine challenge, peak flow diary, skin prick test, and measurement of eosinophil activity in peripheral blood. The psychologic status was assessed by means of the hospital anxiety and depression (HAD) scale questionnaire. A significant correlation was found between anxiety and depression and the report of asthma-related symptoms, such as attacks of breathlessness after activity and waking with attacks of breathlessness ($p < 0.01$). However, there was no significant correlation between anxiety or depression and a self-reported diagnosis of asthma or objective asthma-related variables, such as peak flow variability or response to methacholine. When

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evaluating the combined influence of psychologic factors and objective variables, HAD score correlated independently with reported wheezing ($p < 0.05$), waking with attacks of breathlessness ($p < 0.01$), waking with chest tightness, attacks of breathlessness when at rest, and attacks of breathlessness after activity ($p < 0.001$). We conclude that there is an association between reported respiratory symptoms and psychologic status. However, there was no evidence that patients with diagnosed bronchial asthma had more anxiety and depression than those without asthma. This result indicates that it may be valuable to include psychologic status indicators in respiratory symptom questionnaires.

Development of a Patient-Dedicated, On-Demand, Blood Gas Monitor—CK Mahutte, M Holody, TP Maxwell, PA Chen, SA Sasse. Am J Respir Crit Care Med 1994;149:852.

A new monitor (CDI® 2000) that brings blood gas measurements to the patient's bedside has been developed. To measure blood gases, blood is drawn into the patient's arterial pressure-monitoring line past in-line fluorescent-based sensors. After measurement, the blood is returned to the patient, avoiding blood loss and delays in sample turnaround and reducing the risk of infection to both patient and operator. We assessed this system's performance in vitro with tonometered bovine blood. Bias (mean difference between monitor and tonometered gas or measured pH values) ± the standard deviation (SD) were 0.01 ± 0.02 at pH = 7.39; 0.0 ± 0.7 mm Hg at $P_{CO_2} = 39$ mm Hg; and 2.4 ± 3.2 mm Hg at a $P_{O_2} = 100$ mm Hg ($n = 54$). Changes in hematocrit, blood temperature, or serum sodium concentration did not have clinically significant effects on system performance. Studies in normal volunteers, in whom large changes in blood gases were induced, showed a bias (mean difference between monitor and IL 1306 values) ± SD of 0.00 ± 0.02 for pH, -0.4 ± 2.0 mm Hg for P_{CO_2}, and -3.6 ± 7.7 mm Hg for P_{O_2} ($n = 69$). We conclude from the present study that the performance of this system is comparable to that of conventional blood gas analyzers.

Alveolar-Arterial Oxygen Gradients before Extracorporeal Life Support for Severe Pediatric Respiratory Failure: Improved Outcome for Extracorporeal Life Support-Managed Patients?—FW Moler, JM Palmisano, JR Custer, JN Meliones, RH Bartlett. Crit Care Med 1994;22(4):620.

OBJECTIVE: Recent reports have described the usefulness of the alveolar-arterial oxygen tension difference ($P_{[A-a]O_2}$) in predicting mortality in children with acute respiratory failure managed with mechanical ventilation. We reviewed our experience with extracorporeal life support for acute pediatric respiratory failure and specifically examined $P_{[A-a]O_2}$ measurements during the 24 hrs before extracorporeal life support to determine if defined cutoffs established with conventional mechanical ventilation were applicable to extracorporeal life-support survival. DESIGN: Retrospective, case-series chart review. SETTING: A university tertiary medical center. PATIENTS: Infants and children ($n = 36$), one month to 18 yrs of age, with severe life-threatening respiratory failure who were believed to have failed conventional mechanical ventilatory support. INTERVENTIONS: Veno-venous or veno-arterial extracorporeal life support. MEASUREMENTS & MAIN RESULTS: From 1982 to 1992, we managed 36 pediatric patients with severe respiratory failure using extracorporeal life support. We identified 28 patients who had $P_{[A-a]O_2}$ values of > 400 torr (> 53.3 kPa) for the 24-hr time period before placement on bypass. At the time of bypass initiation, all blood gas and mechanical ventilator parameters except P_{aCO_2} showed trends of worsening pulmonary function, compared with measurements done 24 hrs before bypass initiation. Oxygenation related variables showed statistically significant worsening trends when measured 24 hrs before bypass, compared with the time of bypass: $P_{[A-a]O_2}$ 539 vs 582 torr (71.9 vs 77.6 kPa), $p < 0.01$; P_{aO_2}/F_{IO_2} ratio 70 vs 57 torr (9.3 vs 7.6 kPa), $p < 0.05$; oxygenation index 32 vs 47 cm H_2O/torr, $p < 0.01$; and F_{IO_2} 0.94 vs 0.98, $p < 0.05$. Sixty-one percent of extracorporeal life support-managed patients (17 of 28) survived their life-threatening respiratory illness to be discharged home. CONCLUSIONS: Based on previous reports of the utility of $P_{[A-a]O_2}$ measurements to predict mortality, our preliminary evidence suggests that extracorporeal life support results in 62% survival for pediatric respiratory failure patients predicted to have no chance of survival using conventional mechanical ventilation. Prospective, randomized trials of children with severe acute respiratory failure managed with mechanical ventilation vs extracorporeal life support may be indicated.

Use of Pulse Oximetry To Monitor Venous Saturation during Extracorporeal Life Support—RM Odell, RM Doran, RC Erickson, TC Zeilinger, MG Coyle. Crit Care Med 1994;22(4):626.

OBJECTIVE: To assess the ability of two different pulse oximeters to display continuous venous oxygen saturation through an extracorporeal bypass circuit with a degree of accuracy comparable to direct in-line oximetry. DESIGN: Prospective, comparison study of pulse oximeters (test oximeter 1 or test oximeter 2) and an in-line oximeter (test oximeter 3). SETTING: A tertiary care neonatal intensive care unit. PATIENTS: 65 consecutive neonates with severe cardiorespiratory failure undergoing extracorporeal life support. INTERVENTIONS: The accuracy of the oximeters was determined by simultaneously comparing the saturation displayed by the pulse oximeters (test oximeters 1 and 2) and/or the in-line oximeter (test oximeter 3) with the measured fractional venous oxygen saturation obtained at regular intervals from the extracorporeal circuit. MAIN OUTCOME MEASURES: Venous oxygen saturation was the criterion standard used to determine accuracy. Bias was defined as the mean difference between observed pulse oximeter' or in-line oximeter values and the measured venous oxygen saturation. Mean biases were calculated for venous oxygen saturation measurements between 55% and 99% at intervals of 10%. Precision (the standard deviation of the bias) was calculated for low (55% to 75%), medium (76% to 81%), and high (82% to 99%) venous oxygen saturation values. A total of 983 venous oxygen saturation measurements were made and compared with simultaneous oximeter readings from test oximeter 1 ($n = 600$), test oximeter 2 ($n = 478$), and test oximeter 3 ($n = 587$). RESULTS: Test oximeter 1 was the most precise instrument at each level of venous oxygen saturation (SD 4.0 to 4.8). Test oximeter 3 demonstrated the most consistent mean bias (range 8), but was the most inaccurate oximeter across all levels of venous oxygen saturation. CONCLUSIONS: In addition to its known clinical usefulness, pulse oximetry may serve as an adequate substitute for in-line oximetry during extracorporeal life support.

Closed versus Open Endotracheal Suctioning: Costs and Physiologic Consequences—KL Johnson, PA Kearney, SB Johnson, JB Niblett, NL MacMillan, RE McClain. Crit Care Med 1994;22(4):658.

OBJECTIVE: To examine the physiologic consequences and costs associated with two methods of endotracheal suctioning: closed vs open. DESIGN: A prospective, randomized, controlled study. SETTING: An eight-bed trauma intensive care unit (ICU) in a 460-bed Level I trauma center. PATIENTS: The study included 35 trauma/general surgery patients (16 in the open suction group, 19 in the closed suction group) who were treated with a total of 276 suctioning procedures (127 open, 149 closed). MEASUREMENTS & MAIN RESULTS: Physiologic data collected after hyperoxygenation, immediately after suctioning, and 30 seconds after suctioning, were compared with baseline values. Open endotracheal

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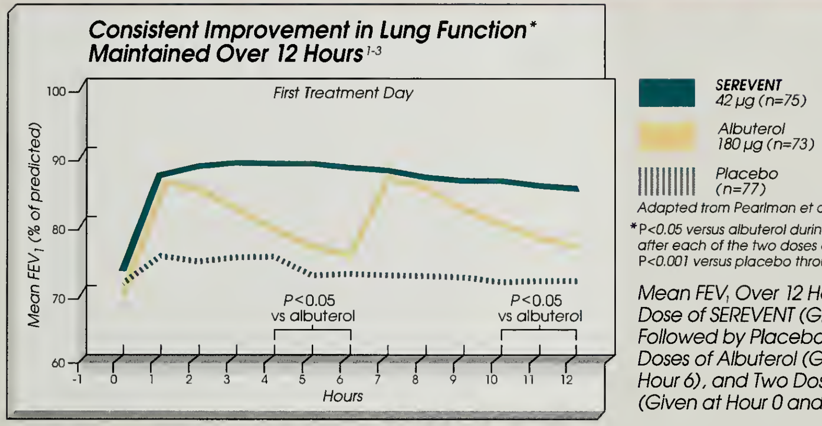

Consistent Improvement in Lung Function* Maintained Over 12 Hours[1-3]

Adapted from Pearlman et al.[1]

*$P<0.05$ versus albuterol during the periods 4 to 6 hours after each of the two doses of albuterol.
$P<0.001$ versus placebo throughout the 12-hour period.

Mean FEV$_1$ Over 12 Hours After the First Dose of SEREVENT (Given at Hour 0 Followed by Placebo at Hour 6), Two Doses of Albuterol (Given at Hour 0 and Hour 6), and Two Doses of Placebo (Given at Hour 0 and Hour 6)

- Proven for 12 weeks,[1,2] maintained over 12 months.[4]
- SEREVENT is indicated for prevention and maintenance treatment of asthma (including nocturnal asthma) in patients 12 years of age and older who require regular treatment with inhaled, short-acting ß$_2$-agonists.
- Convenient twice-daily† dosing.
- Outstanding side effect profile comparable to albuterol.
  - The most common drug-related adverse events reported in clinical trials were headache (10%), tremor (3%), and cough (3%).[2]

New, Twice-Daily

Serevent®

(salmeterol xinafoate)

Inhalation Aerosol

Morning and Evening Inhalation for Active Days and Restful Nights

†Dosing should be two puffs (42 µg) of SEREVENT Inhalation Aerosol, twice daily, morning and evening, approximately 12 hours apart, for the maintenance treatment of asthma. SEREVENT should not be used for the treatment of acute exacerbations.

Please consult Brief Summary of Prescribing Information on the following pages.

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Serevent®
(salmeterol xinafoate)
Inhalation Aerosol

BRIEF SUMMARY

Bronchodilator Aerosol
For Oral Inhalation Only

The following is a brief summary only Before prescribing, see complete prescribing information in Serevent® Inhalation Aerosol product labeling

CONTRAINDICATIONS: Serevent® Inhalation Aerosol is contraindicated in patients with a history of hypersensitivity to any of the components.

WARNINGS: 1. Not for Use to Treat Acute Symptoms; Watch for Increased Need for Short-Acting Beta$_2$-Agonists: Serevent® Inhalation Aerosol should not be used to relieve acute asthma symptoms. If the patient's short-acting, inhaled beta$_2$-agonist becomes less effective, e.g , the patient needs more inhalations than usual, medical evaluation must be obtained immediately and increasing use of Serevent Inhalation Aerosol in this situation is inappropriate. Serevent Inhalation Aerosol should not be used more frequently than twice daily (morning and evening) at the recommended dose. When prescribing Serevent Inhalation Aerosol, patients must be provided with a short-acting, inhaled beta$_2$-agonist (e.g., albuterol) for treatment of symptoms that occur despite regular twice-daily (morning and evening) use of Serevent.

Asthma may deteriorate acutely over a period of hours or chronically over several days. In this setting, increased use of inhaled, short-acting beta$_2$-agonists is a marker of destabilization of asthma and requires re-evaluation of the patient and consideration of alternative treatment regimens, especially inhaled or systemic corticosteroids. If the patient uses four or more inhalations per day of a short-acting beta$_2$-agonist on a regular basis, or if more than one canister (200 inhalations per canister) is used in an 8-week period, then the patient should see the physician for re-evaluation of treatment.

2. Use With Short-Acting Beta$_2$-Agonists: When patients begin treatment with Serevent Inhalation Aerosol, those who have been taking short-acting, inhaled beta$_2$-agonists on a regular daily basis should be advised to discontinue their regular daily-dosing regimen and should be clearly instructed to use short-acting, inhaled beta$_2$-agonists only for symptomatic relief if they develop asthma symptoms while taking Serevent Inhalation Aerosol (see PRECAUTIONS: Drug Interactions).

3. Serevent Inhalation Aerosol is Not a Substitute for Oral or Inhaled Corticosteroids: Patients must be warned not to stop or reduce corticosteroid therapy without medical advice, even if they feel better when they are being treated with Serevent.

4 Do Not Exceed Recommended Dose: As with other beta-adrenergic aerosols, Serevent Inhalation Aerosol should not be used in excess. Fatalities have been reported in association with excessive use of inhaled sympathomimetic drugs. Large doses of inhaled or oral salmeterol (12 to 20 times the recommended dose) have been associated with clinically significant prolongation of the QT$_C$ interval, which has the potential for producing ventricular arrhythmias.

5. Paradoxical Bronchospasm: As with other inhaled asthma medications, paradoxical bronchospasm (which can be life-threatening) has been reported following the use of Serevent Inhalation Aerosol. If it occurs, treatment with Serevent Inhalation Aerosol should be discontinued immediately and alternative therapy instituted.

6. Immediate Hypersensitivity Reactions: Immediate hypersensitivity reactions may occur after administration of Serevent Inhalation Aerosol, as demonstrated by rare cases of urticaria, rash, and bronchospasm.

PRECAUTIONS:

General: 1. Use with Spacer or Other Devices: The safety and effectiveness of Serevent® Inhalation Aerosol when used with a spacer or other devices have not been adequately studied.

2. Cardiovascular and Other Effects: No effect on the cardiovascular system is usually seen after the administration of inhaled salmeterol in recommended doses, but the cardiovascular and central nervous system effects seen with all sympathomimetic drugs (e.g., increased blood pressure, heart rate, excitement) can occur after use of Serevent Inhalation Aerosol and may require discontinuation of the drug Salmeterol, like all sympathomimetic amines, should be used with caution in patients with cardiovascular disorders, especially coronary insufficiency, cardiac arrhythmias, and hypertension; in patients with convulsive disorders or thyrotoxicosis; and in patients who are unusually responsive to sympathomimetic amines.

As has been described with other beta-adrenergic agonist bronchodilators, clinically significant changes in systolic and/or diastolic blood pressure, pulse rate, and electrocardiograms have been seen infrequently in individual patients in controlled clinical studies with salmeterol.

3. Metabolic Effects: Doses of the related beta$_2$-adrenoceptor agonist albuterol, when administered intravenously, have been reported to aggravate pre-existing diabetes mellitus and ketoacidosis. No effects on glucose have been seen with Serevent Inhalation Aerosol at recommended doses. Administration of beta$_2$-adrenoceptor agonists may cause a decrease in serum potassium, possibly through intracellular shunting, which has the potential to increase the likelihood of arrhythmias. The decrease is usually transient, not requiring supplementation.

Clinically significant changes in blood glucose and/or serum potassium were seen rarely during clinical studies with long-term administration of Serevent Inhalation Aerosol at recommended doses.

Information for Patients: See illustrated Patient's Instructions for Use **SHAKE WELL BEFORE USING.** Patients should be given the following information:

1. Not for Use to Treat Acute Symptoms: Serevent Inhalation Aerosol is not meant to relieve acute asthmatic symptoms Acute symptoms should be treated with an inhaled, short-acting bronchodilator that has been prescribed by a physician for symptom relief.

2. Do Not Exceed Recommended Dose: The bronchodilator action of salmeterol usually lasts for at least 12 hours. Therefore it should not be used more often than every 12 hours.

3. Use With Other Medications: While using Serevent Inhalation Aerosol, other inhaled medicines should be taken only as directed by the physician

4 Use with Short-Acting, Inhaled Beta-Agonists: While using Serevent Inhalation Aerosol, medical attention should be sought immediately if the short-acting bronchodilator treatment becomes less effective for symptom relief, if more inhalations than usual are needed, or if more than the maximum number of inhalations of short-acting bronchodilator treatment prescribed for a 24-hour period are needed If the patient uses four or more inhalations per day of a short-acting beta$_2$-agonist on a regular basis, or if more than one canister (200 inhalations per canister) is used in an 8-week period, then the patient should see the physician for re-evaluation of treatment

Patients should be cautioned regarding potential adverse cardiovascular effects, such as palpitations or chest pain, related to the use of additional beta$_2$-agonist.

5. Use of Systemic or Inhaled Steroids: Serevent® (salmeterol xinafoate) Inhalation Aerosol does not replace oral or inhaled corticosteroids; the dosage of these medicines should not be changed and they should not be stopped without consulting the physician, even if the patient feels better.

6. Use for Exercise-Induced Bronchospasm: When using Serevent Inhalation Aerosol to prevent exercise-induced bronchospasm, the dose should be administered at least 30 to 60 minutes before exercise.

Drug Interactions: ***Short-Acting Beta-Agonists:*** In the two 3-month, repetitive-dose clinical trials (n=184), the mean daily need for additional beta$_2$-agonist use was 1 to 1½ inhalations per day, but some patients used more. Eight percent of patients used at least eight inhalations per day at least on one occasion. Six percent used 9 to 12 inhalations at least once. There were 15 patients (8%) who averaged over four inhalations per day Four of these used an average of 8 to 11 inhalations per day. In these 15 patients there was no observed increase in frequency of cardiovascular adverse events. The safety of concomitant use of more than eight inhalations per day of short-acting beta$_2$-agonists with Serevent Inhalation Aerosol has not been established. In 15 patients who experienced worsening of asthma while receiving Serevent Inhalation Aerosol, nebulized albuterol (one dose in most) led to improvement in FEV$_1$ and no increase in occurrence of cardiovascular adverse events.

Monoamine Oxidase Inhibitors and Tricyclic Antidepressants: Salmeterol should be administered with extreme caution to patients being treated with monoamine oxidase inhibitors or tricyclic antidepressants because the action of salmeterol on the vascular system may be potentiated by these agents.

Corticosteroids and Cromoglycate: In clinical trials, inhaled corticosteroids and/or inhaled cromolyn sodium did not alter the safety profile of Serevent Inhalation Aerosol when administered concurrently.

Methylxanthines: The concurrent use of intravenously or orally administered methylxanthines (e.g., aminophylline, theophylline) by patients receiving Serevent Inhalation Aerosol has not been completely evaluated. In one clinical trial, 87 patients receiving Serevent Inhalation Aerosol 42 mcg twice daily concurrently with a theophylline product had adverse event rates similar to those in 71 patients receiving Serevent Inhalation Aerosol without theophylline. Resting heart rates were slightly higher in the patients on theophylline but were little affected by Serevent Inhalation Aerosol therapy.

Carcinogenesis, Mutagenesis, Impairment of Fertility: In an 18-month oral carcinogenicity study in CD-mice, salmeterol xinafoate caused a dose-related increase in the incidence of smooth muscle hyperplasia, cystic glandular hyperplasia, and leiomyomas of the uterus and a dose-related increase in the incidence of cysts in the ovaries. A higher incidence of leiomyosarcomas was not statistically significant, tumor findings were observed at oral doses of 1.4 and 10 mg/kg, which gave 9 and 63 times, respectively, the human exposure based on rodent:human AUC comparisons.

Salmeterol caused a dose-related increase in the incidence of mesovarian leiomyomas and ovarian cysts in Sprague Dawley rats in a 24-month inhalation/oral carcinogenicity study. Tumors were observed in rats receiving doses of 0.68 and 2.58 mg/kg per day (about 55 and 215 times the recommended clinical dose [mg/m^2]). These findings in rodents are similar to those reported previously for other beta-adrenergic agonist drugs. The relevance of these findings to human use is unknown.

No significant effects occurred in mice at 0.2 mg/kg (1.3 times the recommended clinical dose based on comparisons of the AUCs) and in rats at 0.21 mg/kg (15 times the recommended clinical dose on a mg/m^2 basis).

Salmeterol xinafoate produced no detectable or reproducible increases in microbial and mammalian gene mutation *in vitro*. No blastogenic activity occurred *in vitro* in human lymphocytes or *in vivo* in a rat micronucleus test. No effects on fertility were identified in male and female rats treated orally with salmeterol xinafoate at doses up to 2 mg/kg orally (about 160 times the recommended clinical dose on a mg/m^2 basis).

Pregnancy: ***Teratogenic Effects: Pregnancy Category C:*** No significant effects of maternal exposure to oral salmeterol xinafoate occurred in the rat at doses up to the equivalent of about 160 times the recommended clinical dose on a mg/m^2 basis. Dutch rabbit fetuses exposed to salmeterol xinafoate *in utero* exhibited effects characteristically resulting from beta-adrenoceptor stimulation; these included precocious eyelid openings, cleft palate, sternebral fusion, limb and paw flexures, and delayed ossification of the frontal cranial bones. No significant effects occurred at 0.6 mg/kg given orally (12 times the recommended clinical dose based on comparison of the AUCs).

New Zealand White rabbits were less sensitive since only delayed ossification of the frontal bones was seen at 10 mg/kg given orally (approximately 1,600 times the recommended clinical dose on a mg/m^2 basis). Extensive use of other beta-agonists has provided no evidence that these class effects in animals are relevant to use in humans. There are no adequate and well-controlled studies with Serevent Inhalation Aerosol in pregnant women. Serevent Inhalation Aerosol should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Use in Labor and Delivery: There are no well-controlled human studies that have investigated effects of salmeterol on preterm labor or labor at term. Because of the potential for beta-agonist interference with uterine contractility, use of Serevent Inhalation Aerosol during labor should be restricted to those patients in whom the benefits clearly outweigh the risks.

Nursing Mothers: Plasma levels of salmeterol after inhaled therapeutic doses are very low (85 to 200 pg/mL) in humans. In lactating rats dosed with radiolabeled salmeterol, levels of radioactivity were similar in plasma and milk. In rats, concentrations of salmeterol in plasma and milk were similar The xinafoate moiety is also transferred to milk in rats at concentrations of about half the corresponding level in plasma. However, since there is no experience with use of Serevent Inhalation Aerosol by nursing mothers, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the mother. Caution should be exercised when salmeterol xinafoate is administered to a nursing woman.

Pediatric Use: The safety and effectiveness of Serevent Inhalation Aerosol in children younger than 12 years of age have not been established.

Geriatric Use: Of the total number of patients who received Serevent Inhalation Aerosol in all clinical studies, 241 were 65 years and older. Geriatric patients (65 years and older) with reversible obstructive airway disease were evaluated in four well-controlled studies of 3 weeks' to 3 months' duration. Two placebo-controlled, crossover studies evaluated twice-daily dosing with salmeterol for 21 to 28 days in 45 patients. An additional 75 geriatric patients were treated with salmeterol for 3 months in two large parallel-group, multicenter studies. These 120 patients experienced increases in AM and PM peak expiratory flow rate and decreases in diurnal variation in peak expiratory flow rate similar to responses seen in the total populations of the two latter studies. The adverse event type and frequency in geriatric patients were not different from those of the total populations studied

No apparent differences in the efficacy and safety of Serevent Inhalation Aerosol were observed when geriatric patients were compared with younger patients in clinical trials. As with other beta$_2$-agonists, however, special caution should be observed when using Serevent Inhalation Aerosol in elderly patients who have concomitant cardiovascular disease that could be adversely affected by this class of drug. Based on available data, no adjustment of salmeterol dosage in geriatric patients is warranted.

Serevent® (salmeterol xinafoate) Inhalation Aerosol

ADVERSE REACTIONS: Adverse reactions to salmeterol are similar in nature to reactions to other selective beta$_2$-adrenoceptor agonists, i.e., tachycardia; palpitations; immediate hypersensitivity reactions, including urticaria, rash, bronchospasm (see WARNINGS); headache; tremor; nervousness; and paradoxical bronchospasm (see WARNINGS).

Two multicenter, 12-week, controlled studies have evaluated twice-daily doses of Serevent® (salmeterol xinafoate) Inhalation Aerosol in patients 12 years of age and older with asthma The following table reports the incidence of adverse events in these two studies.

Adverse Experience Incidence in Two Large 12-Week Clinical Trials*

Adverse Event Type	Percent of Patients		
	Placebo n=187	Serevent 42 mcg b.i.d. n=184	Albuterol 180 mcg q.i.d. n=185
Ear, nose, and throat			
Upper respiratory tract infection	13	14	16*
Nasopharyngitis	12	14	11
Disease of nasal cavity/sinus	4	6	1
Sinus headache	2	4	<1
Gastrointestinal			
Stomachache	0	4	0
Neurological			
Headache	23	28	27
Tremor	2	4	3
Respiratory			
Cough	6	7	3
Lower respiratory infection	2	4	2

* The only adverse experience classified as serious was one case of upper respiratory tract infection in a patient treated with albuterol.

The table above includes all events (whether considered drug related or nondrug related by the investigator) that occurred at a rate of over 3% in the Serevent Inhalation Aerosol treatment group and were more common in the Serevent Inhalation Aerosol group than in the placebo group

Pharyngitis, allergic rhinitis, dizziness/giddiness, and influenza occurred at 3% or more but were equally common on placebo. Other events occurring in the Serevent Inhalation Aerosol treatment group at a frequency of 1% to 3% were as follows:

Cardiovascular: Tachycardia, palpitations.
Ear, Nose, and Throat: Rhinitis, laryngitis.
Gastrointestinal: Nausea, viral gastroenteritis, nausea and vomiting, diarrhea, abdominal pain.
Hypersensitivity: Urticaria.
Mouth and Teeth: Dental pain.
Musculoskeletal: Pain in joint, back pain, muscle cramp/contraction, myalgia/myositis, muscular soreness.
Neurological: Nervousness, malaise/fatigue
Respiratory: Tracheitis/bronchitis.
Skin: Rash/skin eruption.
Urogenital: Dysmenorrhea.

In small dose-response studies, tremor, nervousness, and palpitations appeared to be dose related.

OVERDOSAGE: Overdosage with salmeterol may be expected to result in exaggeration of the pharmacologic adverse effects associated with beta-adrenoceptor agonists, including tachycardia and/or arrhythmia, tremor, headache, and muscle cramps. Overdosage with salmeterol can lead to clinically significant prolongation of the QT_C interval, which can produce ventricular arrhythmias. Other signs of overdosage may include hypokalemia and hyperglycemia

In these cases, therapy with Serevent® Inhalation Aerosol and all beta-adrenergic–stimulant drugs should be stopped, supportive therapy provided, and judicious use of a beta-adrenergic blocking agent should be considered, bearing in mind the possibility that such agents can produce bronchospasm. Cardiac monitoring is recommended in cases of overdosage

As with all sympathomimetic pressurized aerosol medications, cardiac arrest and even death may be associated with abuse of Serevent Inhalation Aerosol

Rats and dogs survived the maximum practicable inhalation doses of salmeterol of 2.9 and 0.7 mg/kg, respectively. The maximum nonlethal oral doses in mice and rats were approximately 150 mg/kg and >1,000 mg/kg, respectively.

Dialysis is not appropriate treatment for overdosage of Serevent Inhalation Aerosol.

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suctioning resulted in significant increases in mean arterial pressure throughout the suctioning procedure. Both methods resulted in increased mean heart rates. However, 30 seconds after the procedure, the open-suction method was associated with a significantly higher mean heart rate than was the closed method. Closed suctioning was associated with significantly fewer dysrhythmias. Arterial oxygen saturation and systemic venous oxygen saturation decreased with open suctioning. In contrast, arterial oxygen saturation and systemic venous oxygen saturation increased with the closed suction method. There was no difference between the two methods in the occurrence of nosocomial pneumonia. Open endotracheal suctioning cost $1.88 more per patient per day and required more nursing time. CONCLUSIONS: The closed suction method resulted in significantly fewer physiologic disturbances. Closed suctioning appears to be an effective and cost-efficient method of endotracheal suctioning that is associated with fewer suction-induced complications.

Aerosolized Ribavirin in Mechanically Ventilated Children with Respiratory Syncytial Virus Lower Respiratory Tract Disease: A Prospective, Double-Blind, Randomized Trial—KL Meert, AP Sarnaik, MJ Gelmini, MW Lieh-Lai. Crit Care Med 1994;22(4):566.

OBJECTIVE: To study the effect of ribavirin aerosol therapy on the immediate clinical course of mechanically ventilated children with respiratory syncytial virus lower respiratory tract disease. DESIGN: Prospective, randomized, double-blind, placebo-controlled study. SETTING: Pediatric intensive care unit (ICU) of a university teaching hospital. PATIENTS: 41 children requiring mechanical ventilation for respiratory syncytial virus lower respiratory tract disease. INTERVENTIONS: Patients were stratified by the presence or absence of and underlying disease and then randomized to receive aerosolized ribavirin (20 mg/mL) or saline for 18 hours/day for 5 days or until endotracheal extubation, whichever came first. MEASUREMENTS & MAIN RESULTS: Dependent variables included the time course of the illness and the change in F_{IO_2}, ventilatory rate, P_{aO_2}-F_{IO_2} ratio, and ventilatory-efficiency index of patients while they received aerosol therapy. Ribavirin- and placebo-treated patient groups were not significantly different in the number of ventilator days (6.4 ± 6.9 vs 8.2 ± 10.1; p = 0.5), oxygen days (10.8 ± 7.7 vs 12.2 ± 11.8; p = 0.9), ICU days (7.9 ± 7.0 vs 10.3 ± 11.0; p = 0.7), or hospital days (12.9 ± 9.7 vs 16.2 ± 14.0; p = 0.6) after the initiation of aerosol therapy. The change in F_{IO_2}, ventilatory rate, P_{aO_2}-F_{IO_2} ratio, or ventilatory efficiency index did not differ between the two groups. No ventilator malfunction was observed. There were six deaths caused by intractable hypoxemia in patients with underlying cardiopulmonary disease. Four of these deaths were in the placebo group and two in the ribavirin group (p = 0.5). CONCLUSIONS: Ribavirin aerosol therapy can be safely administered to mechanically ventilated children with severe respiratory syncytial virus lower respiratory tract disease. However, this therapy does not appear to affect immediate clinical outcome in such patients.

A Nurse-Delivered Smoking Cessation Intervention among Hospitalized Postoperative Patients—Influence of a Smoking-Related Diagnosis: A Pilot Study—ME Wewers, JM Bowen, AE Stanislaw, VB Desimone. Heart Lung 1994;23(2):151.

OBJECTIVE: To examine the effect of a nurse-delivered smoking cessation intervention on short-term smoking abstinence among hospitalized postoperative patients. DESIGN: Prospective, experimental, random assignment. SETTING: Midwestern university-affiliated tertiary medical center. PATIENTS: Postoperative smokers (n = 80) from cardiovascular, oncology, and general surgical units. OUTCOME MEASURE: Self-reported smoking status and saliva cotinine level at 5 to 6 weeks after hospitalization. INTERVENTION: Three structured smoking cessation sessions during hospitalization, followed by phone calls once a week for 5 weeks after discharge. RESULTS: Of the experimental group patients, 37.8% were abstinent as compared to 25.6% in the usual care group. Abstinence rates of experimental group patients from cardiovascular (40%) and oncology (64.3%) units were higher than that of GS (13.3%) unit patients. Regardless of group assignment, 100% of cardiovascular and oncology patients abstained during hospitalization, compared to only 10.7% of GS patients. CONCLUSIONS: Preliminary results indicate that a nurse-delivered cessation intervention may be effective postoperatively among smokers with an identified smoking-related diagnosis.

Effects of Pressure-Controlled with Different I:E Ratios versus Volume-Controlled Ventilation on Respiratory Mechanics, Gas Exchange, and Hemodynamics in Patients with Adult Respiratory Distress Syndrome—MR Lessard, E Guérot, H Lorino, F Lemaire, L Brochard. Anesthesiology 1994; 80:983.

BACKGROUND: Pressure-controlled (PCV) and pressure-controlled inverse ratio ventilation (PCIRV) have been proposed instead of volume-controlled conventional ratio ventilation (VC) with positive end-expiratory pressure (PEEP) for patients with adult respiratory distress syndrome (ARDS). The advantages advocated with the use of PCIRV are to decrease airway pressures and to improve gas exchange. However, most studies did not compare PCIRV and VC while keeping both the level of ventilation and end-expiratory alveolar pressure (total-PEEP) constant. METHODS: 9 patients with moderate to severe ARDS (lung injury score 2.83 ± 0.18) had their lungs ventilated with VC, PCV with a conventional ratio (I:E 1:2; PC 1/2), and PCIRV (I:E 2:1 and 3:1; PC 2/1 and PC 3/1, respectively). Ventilator settings were adjusted to keep tidal volume, respiratory rate, F_{IO_2}, and total-PEEP constant in every mode. With each mode, a complete set of ventilatory, hemodynamic, and gas exchange parameters was obtained after 30 min. RESULTS: In PC 3/1, the data obtained could not be strictly compared to the other modes because total-PEEP was higher despite external-PEEP being set at zero. For the other modes (VC, PC 1/2, and PC 2/1), despite differences in peak airway pressures, no difference was noted for end-inspiratory and end-expiratory static airway pressures (which better reflect alveolar pressures) nor for lung and respiratory system compliance. Arterial oxygenation deteriorated slightly with PC 2/1 despite a higher mean airway pressure, whereas alveolar ventilation tended to be slightly, but not significantly, improved (lower P_{aCO_2}). A decrease in systolic and mean arterial pressure also was observed with PC 2/1 without other significant hemodynamic change. CONCLUSIONS: In this prospective controlled study, no short-term beneficial effect of PCV or PCIRV could be demonstrated over conventional VC with PEEP in patients with ARDS.

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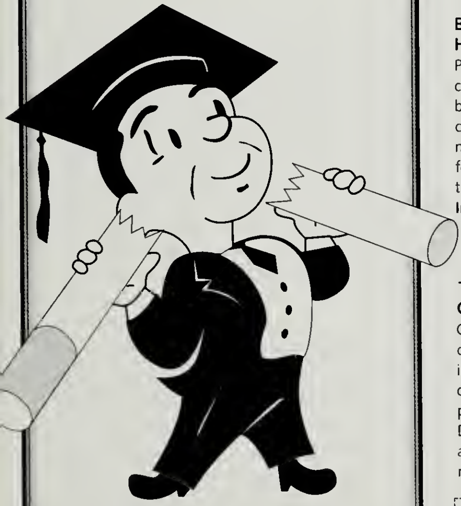

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Why Therapist-Driven Protocols? A Balanced View

Therapist-driven protocols (TDPs), also called patient-driven protocols or respiratory care plans, have been defined as "...patient care plans that are initiated and implemented by credentialed respiratory care workers. These plans have been designed and developed with input from physicians, and are approved for use by the medical staff and governing body of the hospital in which they are used. ...TDPs are by their nature dynamic and flexible, allowing up- or down-regulation of intensity of respiratory services....They must contain clear strategies for various therapeutic interventions."[1]

Though implemented in a small number of hospitals as early as the 1970s, therapist-driven protocols are now being implemented widely. Specifically, the results of a recent poll of 32 attendees at the 1993 American Association for Respiratory Care (AARC) House of Delegates meeting suggested that TDPs are currently used in 40.6% of hospitals and are being planned in another 15.6%.[2] In addition to their increasing use in hospitals, the popularity of therapist-driven protocols has been manifested recently in several other ways, including

1. a proliferation of conferences, both video[3] and live, on the subject of therapist-driven protocols (the recent American Association for Respiratory Care State-of-the-Art conference on therapist-driven protocols, summarized in this issue of RESPIRATORY CARE,[4] is one such example);
2. publication of handbooks and textbooks about therapist-driven protocols;[1,5] and
3. a growing number of papers published in the peer-reviewed literature regarding the implementation and impact of therapist-driven protocols.[6-10]

The use of therapist-driven protocols has evolved from guiding the performance of single respiratory care procedures into programs currently in place within which many individual therapist-driven protocols are amalgamated to guide the performance of a broad range of respiratory care activities. In these larger programs, sometimes called "evaluate-and-treat-programs" or "respiratory therapy consult services," respiratory care practitioners assess patients, determine the specific type of respiratory care needed based on explicit indications (eg, AARC Clinical Practice Guidelines[11-15]), and then deliver the specific treatments to the patients.

Given this meteoric rise in interest and use of therapist-driven protocols, it is logical to ask: What accounts for this growing popularity of TDPs in 1994? At least four forces currently on the health-care scene seem to explain this popularity:

1. Misallocation of respiratory care services (ie, both over-ordering and under-ordering respiratory care) has been exposed in many types of institutions and many different respiratory care services.[16-18] The studies suggesting that respiratory care practitioners can be better allocators of respiratory care services than are other health-care providers have encouraged implementation of therapist-driven protocols.[19-21] Thus, therapist-driven protocols are seen as an exciting strategy to improve the allocation of respiratory care services in this cost-attentive health-care environment.

2. The current climate of hospitals (restructuring to lessen the cost of care) inspires creative strategies for health-care delivery by allied-health providers. Examples of novel approaches include patient-focused care and critical paths. Therapist-driven protocols promise to be a useful adjunct to patient-focused care because TPDs help define the need for respiratory care services and organize their delivery and because TDPs allocate those services most appropriately.

3. The respiratory care community is seeking better ways to optimize respiratory care practitioners' contributions to patients' well-being. In this context, the AARC Clinical Practice Guidelines[11-15] have helped

define the indications for respiratory care modalities and provide the substrate upon which therapist-driven protocols can be developed.

4. Increasing scientific inquiry within the respiratory care community has produced an increasing number of studies regarding the implementation and efficacy of therapist-driven protocols.

Available data about the efficacy of therapist-driven protocols are encouraging. In a variety of institutions in which TDPs have been implemented, use of TDPs has been associated with better allocation of respiratory care services, often with a reduction in the volume and cost of delivering them.[5,7,18] Furthermore, improved allocation has been accomplished with few adverse respiratory events. In this context, the question "Why therapist-driven protocols?" may seem rhetorical. Certainly, TDPs represent a promising new strategy to better allocate respiratory care services while reducing cost and capitalizing upon the indispensable talents of respiratory care practitioners.

Notwithstanding the current excitement about therapist-driven protocols, we should recognize that as with patient-focused care and other new models for delivering health care by allied health practitioners, available data on therapist-driven protocols are preliminary. Few controlled studies are available, and no randomized trial has yet been completed. Furthermore, all of us in respiratory care must be anxious to avoid repeating the "IPPB phenomenon," in which a new treatment strategy was adopted and popularized prematurely, only to discover years later that the initial impressions about its efficacy were grossly overstated. In this spirit of rigorous study, therapist-driven protocols must be examined critically to assure their ability to improve the allocation of respiratory care services, lessen cost, and prevent adverse respiratory events. Even beyond the issue of showing the efficacy of therapist-driven protocols, a fuller understanding of their impact is needed. For example, are the benefits of TDPs generalizable to different types of health-care institutions, such as private hospitals and academic teaching institutions? Will therapist-driven protocols enhance physician trainees' understanding of respiratory care (as hoped), or will TDPs undermine physicians' education? Can respiratory care schools revamp their curricula to meet the significant demands for assessment skills in their graduates? What curricular changes will be required? Can impediments to implementing therapist-driven protocols be overcome? Specifically, will physicians be threatened? Can therapist-driven protocols be married successfully to patient-focused care? These and many other questions should be answered. In the meantime, implementation and study of therapist-driven protocols should proceed, as they represent the new direction of respiratory care.

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Is Our Educational System Adequately Preparing Respiratory Care Practitioners for Therapist-Driven Protocols?

The advent of therapist-driven protocols (TDPs) poses new challenges for respiratory care practitioners (RCPs) and for our educational system. To participate in a therapist-driven protocol program, respiratory care practitioners must have strong assessment skills, must engage in critical thinking to apply algorithms, and must be able to adjust respiratory care plans to meet the patient's changing clinical needs. Preliminary data from a survey of respiratory care educators, staff, and students suggest that performance with algorithms for therapist-driven protocols is disappointing[1,2] but that affiliation with hospitals using therapist-driven protocols enhances practitioners' performance.[1] These observations frame the current challenges for respiratory therapy educators. How can we train respiratory therapy students to perform optimally with therapist-driven protocols? Are structural changes in the respiratory therapy curriculum required to better prepare students to perform? If so, how can these structural changes be accomplished? How can we retrain currently practicing RCPs who find assessment difficult? This editorial offers our thoughts and speculations about these issues.

By way of historical perspective, the profession of respiratory care has undergone pendulum-like changes since the 1970s. Early on, the appeal of respiratory care as a career choice was enhanced by a tight economy. Economic adversity encouraged an influx of highly trained, advanced-degree recipients at a time when formal training programs for respiratory care were very new. As the recession of the 1970s abated, an improving economy pulled applicants away from respiratory care, and school curricula became more goal-oriented, laden with specific content objectives, and product-focused. With the recent return of economic slowdown, applicant pools to respiratory care programs have swelled again, just at a time when professional demands on respiratory care practitioners have grown, especially regarding expanding roles. Respiratory care curricula are, therefore, at a crossroads. A swelling applicant pool allows more curriculum creativity at a time when the rigors of the job market require well-trained therapists who can assume roles as patient assessors. Another critical influence is the current uncertainty about the impact of health-care reform.

How does one survive change, and how should we prepare students to survive when the final form of our health-care system is not yet known? Who are the best survivors of change?—probably those who don't resist because they know that change is inevitable, those who are willing to take risks to make change happen and set the pace for others to follow, and those who stay as informed as possible. Who won't survive?—those who resist change and remain uninformed of the current trends in respiratory care and the expanding role of the RCP.

Preparing RCPs for their new role presents two problems. First, how do you change an RCP who finds patient assessment difficult and lacks confidence regarding clinical decision making? Second, how does one prepare students to assess patients and develop appropriate respiratory care plans? The basic solution is to recruit individuals who are born problem-solvers, those with the enthusiasm and motivation to position themselves as an integral part of the health-care team, and those who when presented with a problem come up with not one but two or three possible solutions and implement one of them. Are we born this way, or do we acquire this skill of analytical thinking?

Piaget was an early explorer of childhood development.[3] His theory was that all learning begins in concrete experience before progressing to abstract representation. He believed that children do not receive knowledge passively but discover and construct knowledge through activities. As they interact with the environment, they begin to form structures for thought; these structures help organize the child's experiences and direct future interaction. The first structures in infants are sensorimotor (eg, eye-hand coordination). As the child grows, more complex mental structures are added. As long as a structure works, it will guide the child's behavior. Conflicting or contradictory states or challenges from the environment create a disequilibrium that forces exchanging old thought processes for new ones. This process is often uncomfortable. Similarly, concrete thinkers are uncomfortable with decision making and with the realization that there may be more than one solution to a problem and that the problem is not clear-cut. If we are confronted with students and staff RCPs who are concrete thinkers regarding problems they encounter in the health-care environment, we must ask ourselves as educators, "How can we influence their thinking?"

We recently assessed whether students and staff RCPs were prepared to make decisions on patient care based on patient case studies and relevant algorithms to guide treatment plans. The participants were presented with a set of algorithms developed using the American Association for Respiratory Care's Clinical Practice Guidelines.[4-6] All student participants were within 2 months of graduation from an AMA-approved program for respiratory care. Our observations suggest that training at clinical sites where TDPs are used is associated with greater proficiency in applying treatment algorithms.[1] Staff RCPs who worked in hospitals where TDPs had been in use for more than a year scored higher when compared to staff in hospitals not using TDPs.[2]

Critical-thinking and analytical skills are taught in some form in most curricula. This teaching may be as basic as the instructor's giving a case presentation exemplifying the problem, the needed information, and the solution. A more advanced approach could be to introduce the student to a patient with a specific problem and to expect that the student will determine the cause, collect and examine additional data, formulate possible treatment modes, provide the treatment, assess the response, and adjust the care plan as a result of the assessment. We need to move away from the "Here are your objectives . . . learn them" instruction method to a total-patient concept of applying those objectives. Adding more opportunities to develop critical-thinking skills may mean that instructors will have to forego their traditional role of lecturer and that students will have to forego their role of passive learner. The AARC's Clinical Practice Guidelines[4-8] offer educators a model for RCP education because they describe the foundation upon which clinical care is based. As educators, we need to teach the Clinical Practice Guidelines so that students will develop assessment skills to apply them. Educators need to encourage critical thinking instead of rote memorization.

One advantage of problem-based learning is that knowledge is better remembered in the context in which it is learned. For example, if students are taught a treatment in the framework of a patient disorder, they are more likely to remember the treatment when confronted with the same disorder again. Thus, seeing several patients who present differently with the same disease process helps students broaden their recognition and, therefore, to develop critical and analytical skills. However, critical thinking requires a willingness on the part of the student to learn. If the students don't willingly participate, they won't learn the material. As educators, we need to be open to student criticism and state our beliefs on a subject, acknowledging that our solution is not the only possibility. This approach gives the student the chance to perceive us as truly objective and to begin to perceive knowledge not as hard and fast truth, but as a critical approach to a body of information. As educators, we cannot be "black-or-white," "yes-or-no" individuals.

Educational institutions may benefit from incorporating the Clinical Practice Guidelines and algorithms into curricula, thereby providing the students with many opportunities to develop patient care plans and to assess the patient's response to the treatment. Requiring that students demonstrate proficiency in developing an appropriate care plan seems advisable. In the hospital setting, we have found that daily consult rounds help to encourage the discussion of care plans that have already been implemented. During this exercise, therapists are often required to defend their care plans, which helps to encourage open discussion and expose different approaches to the care of a single patient. Perhaps by meeting the challenge of a new way of thinking, we will begin to realize that our students are not really fixed, concrete, and unimaginative thinkers, but rather victims who have had their imagination suppressed by academic environments that foster content learning at the expense of expansive thinking.

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Research on Resuscitation by RCPs Is Long Overdue

In this issue of RESPIRATORY CARE, a report on 37 simulated cardiac arrests (SCAs) is presented.[1] Studies such as this one should stimulate more research by respiratory care practitioners (RCPs) on the quality of resuscitation in acute-care hospitals. The cardiac-arrest teams in most hospitals include at least one respiratory care practitioner who responds to in-hospital resuscitations, and who functions as a primary member of that team. However, questions remain—How effective is the RCP's performance during resuscitations? Are RCPs qualified to assume this responsibility by virtue of their training? Should RCPs who carry the code beeper maintain current training in advanced cardiac life support (ACLS)?

The leadership and responsibility assumed by the RCP on the code team varies among and within hospitals. The study by Palmisano et al[1] reports that RCPs in their facility had a median response time (from activation of the SCA) of 3.2 minutes; yet, endotracheal intubation was not accomplished until 6.0 minutes had passed. Thalman and coworkers[2] from the Respiratory Care Department at Duke University Medical Center have demonstrated that RCPs can perform emergency endotracheal intubations with a success rate comparable to that of paramedics. The recently published AARC Clinical Practice Guideline for resuscitation in acute-care hospitals[3] lists endotracheal intubation and many other tasks requiring advanced training as a responsibility of Level II personnel (RRTs, MDs, RNs).

A question that begs a more definitive answer is—Does the interdisciplinary cross-training of cardiac-arrest team members using American Heart Association (AHA) ACLS Provider courses allow performance of tasks normally done by other members of the team in their absence—ie, cross-performance? It is our opinion that RCPs should assume five critical tasks when they are the best trained responders at the scene:

- emergency airway management consisting of manual ventilation, oxygen administration, and tracheal intubation;
- countershock of ventricular fibrillation or pulseless ventricular tachycardia with manual or semi-automatic defibrillators;
- chest compressions;
- tracheal instillation of cardiac drugs (ie, epinephrine, lidocaine, atropine) before an I.V. line is established; and
- arterial blood gas and pH determinations.

We believe that because RCPs are primary responders to in-hospital resuscitations they have an unique opportunity to study and improve several aspects of resuscitation-team performance. The evidence that early defibrillation to reverse ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT) improves outcome has resulted in an AHA recommendation that three consecutive countershocks be delivered at the beginning of the resuscitation—before other measures are undertaken.[4] The next critical step in the VF-pulseless VT algorithm is translaryngeal intubation. The need for these critical early interventions underscores the utility of cross- training of the resuscitation team members through ACLS courses. RCPs with current ACLS provider cards have demonstrated their ability to deliver three countershocks for VF and pulseless VT and also their skill with advanced airway management, emergency tracheal intubation, and tracheal instillation of cardiac drugs.

A study by Batenhorst et al[5] evaluated 516 cardiopulmonary resuscitation events and found no correlation between time of day and arrest incidence. Based on these data, we believe that 24-hour staffing for resuscitation teams is critical. Recently, Birnbaum and his colleagues[6] documented a clear need for ACLS training in small rural community hospitals where experience in managing patients with ischemic heart disease was meager compared to that of large, tertiary centers. Eliadi and co-workers[7] using a mock-code program identified deficiencies in code-cart equipment and supplies, team members' response and communication, and performance in areas other than ICUs (eg, radiology, clinics). Poor performance was related to unfamiliarity with ACLS protocols, standard resuscitation equipment, and code-cart organization.

In the SCA study by Palmisano et al,[1] a major concern is the delay of more than 2 minutes (while awaiting the arrival of the resuscitation team) before supplemental oxygen was administered. A similar observation was made by Sullivan and Guyatt[8] in their study using SCAs. The American Heart Association's Emergency Cardiac Care-Basic Life Support Subcommittee has established that oxygen should be administered by first responders and recommends that mouth-to-mask devices that have oxygen inlet ports be available. The AHA has only recently issued its recommendation that the administration of oxygen by first responders be emphasized in all basic life suppport courses taught to health-care providers.[9]

Table 1. Topics of Investigation for Respiratory Care Practitioners Who Participate in Resuscitations

Clinical Concerns

- How important is it that an endotracheal tube be placed early in the resuscitation?
- What is the delay in administering supplemental oxygen?
- What is the measured tidal volume, F_{IO_2}, and minute volume during bag-to-mask ventilation administered during resuscitation, and do they affect patient outcome?
- What is the optimal oxygen flow with mouth-to-mask ventilation?

Equipment Concerns

- What percent of hospitals/bed spaces is equipped with mouth-to-mask devices with O_2 inlets?
- Are the adjunctive parts of airway equipment (eg, connecting tubing, flowmeter, and oxygen) available?
- How long does it take for the code cart and defibrillator to arrive, and does this relate to patient outcome?

Personnel Concerns

- Are RCPs universally available for resuscitations?
- What special training, experience, education, or credential is required for an RCP who carries the code beeper?
- What is the minimum allowable time for the RCP to arrive at a cardiac arrest?
- Should the RCP wait for an anesthesiologist or perform emergency endotracheal intubation?
- With what frequency do RCPs deliver countershock for ventricular fibrillation or pulseless ventricular tachycardia?
- Are SCAs a valid surrogate for measuring resuscitation-team performance?

Much research is needed on the topic of in-hospital resuscitation. Improvement of performance and documentation of patient outcomes are essential. Table 1 lists some questions that RCPs who participate in resuscitations could reasonably be expected to research, and Table 2 lists some of the information that we believe should be collected from each resuscitation performed and entered into a computerized database to help answer those questions.

Table 2. Essential Information for a Computerized Database on Cardiopulmonary Resuscitation Performance

Institutional Data

- Trauma designation
- Number of total beds, ICU beds, and admissions/year
- Respiratory Care Department—ventilator days/year, FTEs, staff credentials, and level of post-secondary education

Patient Data

- Medical history
- Personal demographics
- Details of current illness

Resuscitation Data

- Location/unit of occurrence
- Elapsed time from the emergency call to the arrival of resuscitation team members
- Quality of airway management initiated by the RCP at the resuscitation scene and elapsed time until successful intubation of the patient's trachea
- Credentials (ACLS, BLS) and skills (certified to intubate, defibrillate, or medicate) of resuscitation team members
- Availability or arrival time of adjunct airway equipment (intubation & suction equipment)
- Endotracheal intubation failures—misplacement (esophageal), equipment malfunction, visualization difficulties
- Drug administration by tracheal instillation—drug name, dose, timing, and credential of administrant
- Arterial blood and pH determinations—number, timing, and credentials of personnel involved
- Elapsed time from arterial sampling to arrival of ABG reports

Can ACLS training of RCPs improve the morbidity and mortality of patients who are resuscitated in acute-care hospitals? Birnbaum et al[10] reported that ACLS training for 3 hours/week over 12 weeks in 7 small rural hospitals improved mortality rates from ischemic heart disease from 17.4% in the year before training to 13.1% after training. He also reported that 6 respiratory therapists improved their precourse knowledge of ACLS by 45% upon completion of the 12-week course. These data imply that ACLS-trained RCPs can make a difference in patient outcome, but prospective controlled data are needed to confirm this.

In summary, RCPs with ACLS training are in a prime position to assume more responsibility during cardiopulmonary resuscitation within acute care facilities. They should be prominent members of the 'code team'—concerned with the entire team's performance—and be actively involved in ACLS training. The first step in attaining that goal is to study the current levels of RCP competence in ACLS. We commend Palmisano et al for their use of SCAs to assess the performance of their hospital's resuscitation effort and hope that their work will stimulate others to collect and report their data on performance of in-hospital cardiopulmonary resuscitation.

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Benefits Associated with a Respiratory Care Assessment-Treatment Program: Results of a Pilot Study

Kevin L Shrake MA RRT, John E Scaggs BS RRT, Kevin R England BA, Joseph Q Henkle MD, and Lanie E Eagleton MD

BACKGROUND: During the months of July, August, and September 1993, we implemented a respiratory care assessment-treatment pilot study on the orthopedic surgery floor in our hospital. The purpose of the study was to determine feasibility and establish cost-effective treatment plans with quality patient outcomes, while maintaining appropriate communications with physicians and nursing staff. STUDY DEVELOPMENT & IMPLEMENTATION: The study's Task Force developed protocols for oxygen therapy, aerosolized medication therapy, volume expansion therapy, and bronchial hygiene therapy using the American Association for Respiratory Care's Clinical Practice Guidelines as supporting documents. Meetings were held with the orthopedic surgeons and nursing staff to inform them of the key components of the pilot program. Ten patient evaluators were trained to assess patients and implement treatment plans. EVALUATION METHODS: A reference book was established that contained the protocols and support material. Patient outcomes were evaluated using previously established quality assurance plans. The length of stay, procedural volume, and cost data were collected. EVALUATION RESULTS: More than 50% of the orders received during the pilot program were for "Respiratory Care Protocol." This allowed the patient care evaluator the flexibility to initiate one of the approved protocols if indicated. No changes in patient outcomes were noted and average length of stay remained unchanged during the pilot study compared to the base period. Treatment volumes decreased, resulting in identified cost savings of $5,318 during the study. Nurses and physicians supported protocol implementation, and increased communication among caregivers was documented. We believe that professionalism of the RCPs was enhanced without compromising the ultimate decision-making responsibilities of the physician. CONCLUSIONS: The use of respiratory care protocols is an acceptable method of developing clinically effective and fiscally responsible care plans. RCPs at our hospital were able to implement care plans that resulted in cost savings without a measured change in patient outcomes. Approval has been extended from the Executive Committee of the medical staff to expand hospital-wide. [Respir Care 1994;39(7):715-724.]

Background

A respiratory care evaluation system was established in our 560-bed, university-affiliated teaching hospital in 1978 to enhance the evaluation skills of our practitioners and control utilization of services.[1] The primary motivation for the program at that time was to ensure the delivery of all ordered therapy during the chronic personnel shortages that characterized the 1970s. Other institutions have

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documented the establishment of similar programs and have reported success.[2-4]

In 1984, the Medicare Prospective Payment System (PPS)[5] established for the first time a true financial incentive for such programs. Respiratory care departments became cost centers (as opposed to being revenue centers) for all patients on fixed payment. Our 1978 system was effective in achieving its goals, but it was labor intensive and had limited flexibility. We sought additional practitioner decision-making authority to achieve the cost savings and timely treatment plans needed for the increased number of fixed-payment and managed-care patients treated during the 1990s.

Appropriate utilization of hospital resources is an essential part of controlling costs and is congruent with anticipated health-care reform proposals. Patient assessment-treatment programs can result in cost savings either by eliminating unnecessary care or by decreasing length of stay through appropriate treatment[4-10] and can be implemented without adverse changes in clinical outcome.[3,10]

During July, August, and September 1993, a pilot respiratory care assessment-treatment program was implemented on the orthopedic surgery floor (OSF) in our institution. The goals of this program were to establish cost-effective treatment plans with equal or improved quality of patient care as compared to that obtained during a base period. In addition, we wanted to improve the communications with physicians and nurses as evaluated by a current versus base-period comparison of the methods and frequency of case-management-related contacts. The OSF was selected because of the willingness of the medical leadership on that unit to evaluate current treatment plans and identify opportunities for cost reduction.

Similar assessment-treatment programs have been reported with long-term success.[6-8] Our plan was to determine the effectiveness of such a process on a pilot unit in our hospital. During the pilot study, we would collect data, gain experience and establish methods, and refine the program as results dictated. If the overall results proved favorable, we would expand the system hospital-wide.

Study Development & Implementation

Plan for Development

The first step in initiating the patient assessment-treatment program was to establish a plan for development. Figure 1 details that plan.

Task Force Selection

A task force, chaired by the Administrative Director and including the Technical Director, a registered nurse-registered therapist from the Pulmonary Rehabilitation Unit, an instructor from the school of respiratory therapy, and three experienced staff respiratory therapists, was selected to develop respiratory care protocols.

Protocol Development

Prior to the first meeting of the Task Force, the Medical Director for Cardio-Pulmonary Services reviewed an outline of the proposed protocol process. We believed that an

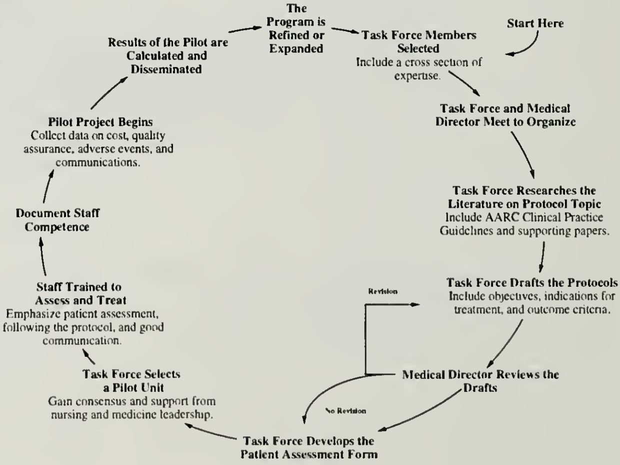

Start Here
Task Force Members Selected
Include a cross section of expertise.
Task Force and Medical Director Meet to Organize
Task Force Researches the Literature on Protocol Topic
Include AARC Clinical Practice Guidelines and supporting papers.
Task Force Drafts the Protocols
Include objectives, indications for treatment, and outcome criteria.
Revision
Medical Director Reviews the Drafts
No Revision
Task Force Develops the Patient Assessment Form
Task Force Selects a Pilot Unit
Gain consensus and support from nursing and medicine leadership.
Staff Trained to Assess and Treat
Emphasize patient assessment, following the protocol, and good communication.
Document Staff Competence
Pilot Project Begins
Collect data on cost, quality assurance, adverse events, and communications.
Results of the Pilot are Calculated and Disseminated
The Program is Refined or Expanded

Fig. 1. This diagram shows our "12-step program" for successful implementation of a respiratory therapist assess-and-treat protocol.

important first step was to obtain approval for a basic structure within which the Task Force would work. The first meeting was devoted to a review of the literature to determine what help was available for protocol development. The Clinical Practice Guidelines developed by the American Association for Respiratory Care (AARC) provided support documents for the development of our hospital-specific protocols.[11-13] We established protocols for oxygen therapy, aerosolized medication therapy, volume expansion therapy, and bronchial hygiene therapy. Members of the Task Force used summary documents[11-14] and associated primary references to write rough drafts for group review. In addition, a patient-assessment form was developed as a part of each protocol as shown in the example in Figure 2.

Our Medical Director and his senior partner reviewed the drafts and offered suggestions. The most helpful bit of advice was that the draft protocols were too detailed to use to 'sell' the concept to physicians. We needed a more succinct set of documents that included primarily indications, therapeutic objectives, outcome criteria, and standard treatment formats. An example of our protocol for aerosolized medication therapy (as it was ultimately adopted) is shown in Figure 3. We decided to keep the longer versions of our protocols (including such things as contraindications, documentation, and when to make physician contacts) as training documents for our evaluators.

Staff Preparation

Once the protocols had been developed and approved by our Medical Director, the Task Force moved to fashion a pilot project that would allow us to gain experience, refine procedures, and collect the data necessary for process evaluation and ultimate acceptance or rejection of the process. The OSF was proposed due to its moderate size and defined group of physicians and residents caring for patients. Members of the Task Force also believed that some opportunities existed for decreases in therapy utilization in this group of patients. Our Medical Director met with the Administrative Director and the key medical leadership on the OSF to propose a 3-month pilot study. The Administrative Director also met with the Nurse Manager of the unit to explain the concept. After receiving initial approval from these individuals, we were invited to attend their respective staff meetings for final approval.

Patient Evaluators

Once the pilot study had been approved, members of the Task Force selected and trained 10 patient evaluators in protocol use. This allowed for 24 hour/day, 7 day/week coverage for the anticipated work load of 100 patients/month. The training time entailed a review of patient-assessment skills and familiarity with the protocols and the required documentation and communication with the nurses and physicians. Test patients were selected prior to the implementation of the study to provide experience. The initiation date was established to coincide with the start of a new OSF resident rotation.

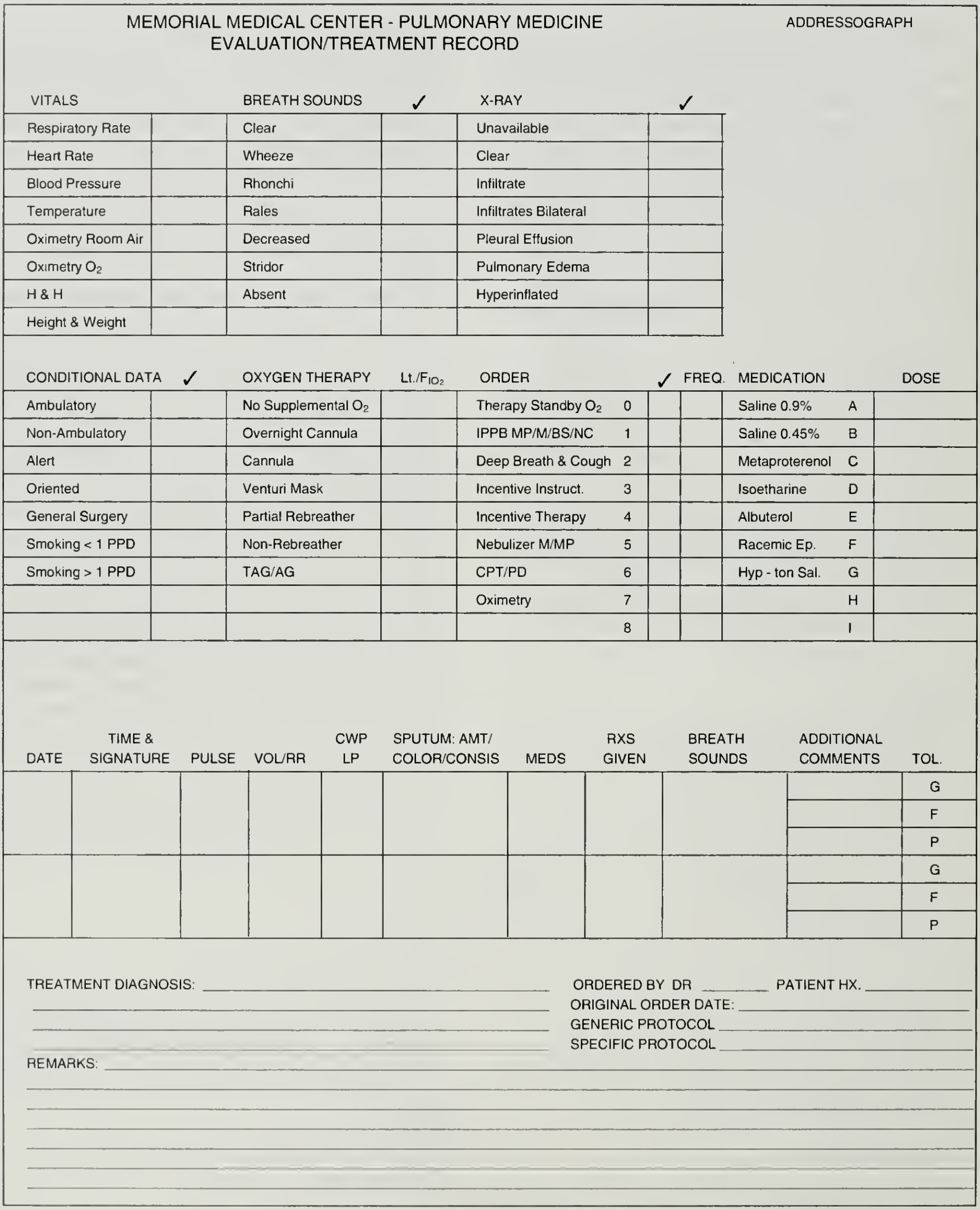
Evaluation Methods

Evaluation Period

We chose to compare our pilot data to the 6 months of October 1992 through March 1993 rather than to the 3 months of July through September of 1992. The Clinical Resource Management Department had been sharing length-of-stay and cost information with the orthopedic surgeons for more than 1 year prior to our pilot program. This had already resulted in decreases in respiratory therapy utilization. Comparing the results of our pilot study with the same months of the previous year would have shown a more dramatic cost savings, part of which would not have been specifically related to the protocol process. This decision had potential limitations by not allowing for natural seasonal variations in work load that sometimes occur during different time periods. However, the number of patients seen per month during the study was nearly identical to the number seen in the selected base period. Therefore, any changes in utilization could be attributed primarily to the pilot study interventions. We chose a 3-month buffer between the base period and the pilot period in an attempt to make results more meaningful because we had observed that simply talking about the proposed study prior to implementation had altered the practice patterns of some physicians. We believe that providing the buffer allowed for more accurate assessment of the impact of the protocol process.

Record Review

Physician orders and assessment sheets for each protocol patient were reviewed. The assessment sheets, a question-comment log, copies of protocols, and support materials were kept in a centrally located reference book. Data from these records were presented to the medical leadership on the OSF on a weekly basis for 1 month and then monthly during the last 2 months of the project. This equipped them to report to their fellow orthopedic surgeons during staff meetings and offer opinions and advice to the Respiratory Care Department regarding changes. There were also daily communications with the resident physicians and nursing staff. These discussions (documented in the question-comment log) provided for information exchange and general debate about treatment plans.



MEMORIAL MEDICAL CENTER - PULMONARY MEDICINE
EVALUATION/TREATMENT RECORD

ADDRESSOGRAPH

VITALS		BREATH SOUNDS	✓	X-RAY	✓
Respiratory Rate		Clear		Unavailable	
Heart Rate		Wheeze		Clear	
Blood Pressure		Rhonchi		Infiltrate	
Temperature		Rales		Infiltrates Bilateral	
Oximetry Room Air		Decreased		Pleural Effusion	
Oximetry O_2		Stridor		Pulmonary Edema	
H & H		Absent		Hyperinflated	
Height & Weight					

CONDITIONAL DATA	✓	OXYGEN THERAPY	Lt./F_{IO_2}	ORDER		✓	FREQ.	MEDICATION		DOSE
Ambulatory		No Supplemental O_2		Therapy Standby O_2	0			Saline 0.9%	A	
Non-Ambulatory		Overnight Cannula		IPPB MP/M/BS/NC	1			Saline 0.45%	B	
Alert		Cannula		Deep Breath & Cough	2			Metaproterenol	C	
Oriented		Venturi Mask		Incentive Instruct.	3			Isoetharine	D	
General Surgery		Partial Rebreather		Incentive Therapy	4			Albuterol	E	
Smoking < 1 PPD		Non-Rebreather		Nebulizer M/MP	5			Racemic Ep.	F	
Smoking > 1 PPD		TAG/AG		CPT/PD	6			Hyp - ton Sal.	G	
				Oximetry	7				H	
					8				I	

DATE	TIME & SIGNATURE	PULSE	VOL/RR	CWP LP	SPUTUM: AMT/ COLOR/CONSIS	MEDS	RXS GIVEN	BREATH SOUNDS	ADDITIONAL COMMENTS	TOL.
										G
										F
										P
										G
										F
										P

TREATMENT DIAGNOSIS: ______________________

ORDERED BY DR ________ PATIENT HX. ________

ORIGINAL ORDER DATE: ________

GENERIC PROTOCOL ________

SPECIFIC PROTOCOL ________

REMARKS: ______________________

Fig. 2. This is an example of the combined patient assessment/treatment sheet used for respiratory care protocol patients. Assessment and treatment were combined on one sheet to simplify paperwork. It is provided as a 3-part form to provide a chart copy, billing copy, and patient follow-up copy.

PULMONARY MEDICINE
ASSESSMENT & TREATMENT PROTOCOL

Index #______________________________
Effective Date__________ Review Date__________

AEROSOLIZED MEDICATION THERAPY PROTOCOL

PURPOSE: To administer aerosolized medication by the appropriate delivery system.

THERAPEUTIC OBJECTIVES:

A. Improve pulmonary airflow
B. Improve sputum clearance
C. Relieve or prevent dyspnea
D. Improve oxygenation and/or carbon dioxide elimination
E. To relieve airway edema

INDICATIONS:

A. Wheezing
B. Impaired clearance of secretions from the lungs
C. Tracheobronchial mucosal congestion and laryngeal stridor

CRITERIA FOR METHOD OF DELIVERY:

A. IPPB is indicated if:

1. Ventilation is inadequate as in neuromuscular disease, kyphoscoliosis, or when vital capacity is < 30% of predicted.
2. Refractory atelectasis has developed.

B. Metered Dose Inhaler (MDI) with spacer (eg, Aerochamber) is indicated if:

1. Medication(s) available in this delivery method
2. Patient is alert/cooperative
3. Able to perform 3 second breath hold
4. Patient has demonstrated ability to use MDI effectively

C. Small Volume, Hand-Held Nebulizer (HHN) is indicated if:

1. Medication is not available in MDI form
2. Ventilation is not adequate
3. Patient demonstrates inability to use MDI effectively

STANDARD PROTOCOL:

A beta agonist will be used QID & PRN as the standard for bronchodilator therapy. The current drug utilized is Ventolin 1/2 cc diluted with normal saline for IPPB and HHN or 3-4 puffs by MDI. Atrovent solution 2.5 cc may be added in COPD patients for maximum bronchodilator effect.

NOTE: If the Respiratory Care Practitioner believes that the patient may benefit from vasoconstrictors such as Vaponephrine, an anti-inflammatory agent such as Intal, or a mucolytic such as Mucomyst, a physician contact will be made.

OUTCOME CRITERIA:

A. Guidelines/Warnings: Evaluate patient's clinical status for changes that indicate a need for change in the treatment plan such as:

1. A pulse greater than 120 bpm, or if a pulse increase of 20 bpm occurs within 30 minutes of discontinuing therapy
2. Significant worsening of dyspnea or wheezing occurring during or within 30 minutes of discontinuing therapy
3. Worsening of patient's sensorium (eg, patient becomes confused or obtunded and unable to follow directions)
4. Worsening of patient's chest x-ray
5. Change in sputum (eg, increased pulmonary infiltrate, which might indicate need for volume expansion therapy)
6. Patient has difficulty coughing up secretions, which might indicate need for acetylcysteine and/or bronchial-hygiene therapy

B. Measurement of spirometry or peak flow may be indicated in select patients.
C. In select patients, after initial instruction, MDI therapy may be self-administered by the patient under supervision of the nursing staff.
D. Aerosol therapy frequency may be tapered as symptoms/indications diminish.
E. Aerosolized medication(s) may be discontinued when goals have been met and patient has been symptom free for 24 hours.

Fig. 3. This is an example of the protocol for aerosolized medication therapy utilized in our patient assessment/treatment program. All protocols are physician approved and are reviewed and revised every 6 months.

Quality Assurance Data

Quality assurance data were evaluated by physicians during mortality and morbidity conferences. The number of deaths and pulmonary complications on the OSF during the pilot study were compared to a 6-month base period. In addition, the hospital's Quality Assurance Department continued to do routine chart review of selected patients on the OSF.

Clinical Resource Management Data

The Clinical Resource Management Department of the hospital provided assistance in collecting length-of-stay, procedural volume, and cost information on all patients during the pilot study compared to the 6-month base period. We were able to compare changes in these three categories and quantitate their impact on our protocol system.

Evaluation Results

Participation in Protocol

Three hundred and three (303) patients were evaluated during the 3-month pilot program for needs ranging from short-term oxygen therapy to more complex situations requiring bronchodilator therapy, sleep apnea monitoring, and pulmonary rehabilitation. More than 50% of the orders received were for "Respiratory Care Protocol." Table 1 summarizes the breakdown of the therapy administered.

Table 1. Respiratory Care Delivered via Protocol* during the 3-Month Pilot Study

Type of Therapy Administered	Number of Patients
Incentive spirometry instruction	59
Deep breathing-cough instruction	84
Bronchodilator therapy-small volume nebulizer	22
Volume-oriented IPPB	2
Pulmonary rehabilitation referral	1

*All patients receiving oxygen therapy were weaned according to protocol

Cost Reductions

During the pilot study, 59 patients received incentive spirometry instruction followed by nursing-encouraged self-administration. Prior to institution of the pilot protocol, these patients would have incurred the cost of twice-daily therapy for 2 days. Supervised deep breathing and cough instruction were provided to 84 patients at no charge. All of these patients would have received incentive spirometry twice daily for 2 days, prior to the pilot project. Only 22 patients received bronchodilator by small-volume nebulization.

The remaining orders were for specific therapeutic modalities. When these specific orders were received, a patient-care evaluator assessed the patient's clinical status versus the indications for the ordered therapy as listed in our protocols. If the patient met the criteria for the therapy, it was initiated according to protocol. If there were no apparent indications for therapy, the evaluator contacted the ordering physician to discuss the intent of the order. Table 2 provides a breakdown of what was administered in this group. Eighteen patients for whom therapy had been ordered (16 incentive spirometry, 2 small-volume nebulizer) did not receive therapy as a result of the RCP's evaluation. Once again, all 78 patients who did receive incentive spirometry instruction would have incurred the additional cost of twice-daily therapy for 2 days, prior to institution of the protocol.

Table 2. Specific Requests* for Respiratory Care (Other Than by Protocol) Ordered during the 3-Month Pilot Study

Type of Therapy	Number of Orders	Number Not Started
Incentive spirometry instruction	78	16
Bronchodilator therapy—small-volume nebulizer	11	2
Apnea monitor	2	0

*All patients receiving oxygen therapy were weaned according to protocol.

Quality Assurance Results

The Quality Assurance Department performed a retrospective chart review to evaluate the incidence of pulmonary complications among patients in our pilot project. Their review confirmed only one patient with a pulmonary complication—an 82-year-old woman who developed multiple medical problems postoperatively. The patient was made a "no stat code" (ie, do not resuscitate) with comfort measures only, in accordance with her family's request. The patient expired and the autopsy cause of death was listed as pneumonia. The Quality Assurance Department believed that this patient would have done poorly regardless of the respiratory care regimen utilized. In comparison, during the base period, one patient died, with the cause of death listed as pneumonia.

In some of our frequent discussions with the orthopedic residents, they identified three patients whom they felt would benefit from respiratory care more aggressive than was being provided via protocol. These patients were heavy smokers who did not cooperate to meet their postoperative need to deep breathe and cough. In these cases, the orthopedic residents ordered bronchodilator therapy via small-volume nebulizer to improve mucociliary clearance.[15,16] The frequency of disagreements in care plans during the study period was unchanged from the base period.

As a result of specific clinical resource management initiatives, total average length of stay of patients on the OSF had been gradually decreasing. During the base period, the length of stay was 6.9 days and remained at this level during the pilot. These data suggest that the protocol process did not have an adverse effect on length of stay.

Communication among Staff

The communication process among the RCPs and the physicians and nurses was enhanced during the pilot program. A combination of 609 initial and follow-up evaluations was performed during the pilot study. Each of these resulted in mandatory contacts with the nurses that had not been occurring prior to the project. Improved communication was documented not only through the increased contact but also anecdotally via the willingness of the nurses to call the RCP for patient evaluation. This had happened infrequently prior to the project but became a common occurrence during the project. Subjective improvement in the respect accorded by the nurses was also reported by the RCPs participating in patient evaluations. The frequency of physician communications also increased due to daily conversations about care plans and the documentation of each patient assessment in the progress notes. Physician contacts prior to the pilot project were much less frequent and usually entailed a phone contact to discontinue treatment that was no longer necessary.

Cost Savings

The cost savings identified during the project are summarized in Table 3. The utilization and cost data were extracted from our institution's internal cost accounting, case mix, and patient-billing systems. The cost savings identified during the project include only the variable costs associated with performing those particular procedures. Included in our institution's variable costs are direct labor, materials, and fringe benefits. Allocated fixed costs have been excluded from this analysis as those amounts tend not to fluctuate with changes in utilization. As a result, the variable amount measures the actual reduction in operating expenses resulting from the Respiratory Care Department's assessment-treatment initiative. The average cost and utilization figures reflected within Table 3 are based on total discharges from the OSF for each respective time period. (Outliers as defined by the Health Care Financing Administration have been excluded.) As noted, the reduction in operating expenses during the 3-month pilot study was $17.55/patient, thus resulting in a total savings of $5,318. If utilization and patient referrals remain steady, savings of approximately $21,250/year would be realized.

Discussion

Affective Strategy

Understanding that change brings forth fear and concern as well as growth, we prepared to meet the anticipated questions of those physicians and nurses involved in the pilot study. Initially, there were numerous physician doubts, possibly associated with the anticipated loss of control of management of the patients for which they were ultimately responsible. The pilot study was approved only after many verbal and written exchanges with physicians that stressed that respiratory protocols were flexible tools. Physicians were encouraged to order respiratory care protocols and were assured that written conclusions regarding the patient assessment would be entered in the progress notes for their review.

Anecdotal Observations

Respiratory protocols quickly proved to be convenient, time-saving tools for the physician. On one occasion, an orthopedic surgeon was contacted concerning nebulizer treatments for one of his patients with a history of asthma. The particular physician shared the RCP's view, but stated he was uncertain about what to order. He was pleased when told he could simply order "Respiratory Care Protocol" and the appropriate therapy would be administered. He was then able to focus upon the patient's orthopedic condition.

The staff nurses were also apprehensive about their new role. Traditionally, RCPs and nurses though serving the same patients did so independently with a minimum of communication or interaction. As a rule, nurses contacted the attending physician directly about suspected or identified patient pulmonary needs. As a consequence, orders were commonly written on the basis of nursing assessment by physicians who often were unable to personally assess the patient's pulmonary status at the given time. Therefore, RCPs frequently carried out orders with little participation in the assessment and decision-making process.

Our respiratory protocols created a team image, bringing together the nurse and RCP from their more separate roles. At first there was hesitation, but soon nurses were contacting RCPs regarding their patients' respiratory requirements. Protocol patients were no longer so much "Nursing's patient" or "Respiratory Care's patient," but rather a combined responsibility of both caregivers, a collaboration created by a program promoting communication.

Our enhanced interaction with nurses bolstered their confidence in RCPs, trusting that we would professionally

Table 3. Financial Impact of Respiratory Care Assessment-Treatment Program on an Orthopedic Surgery Unit during a 3-Month Pilot Program

		Base Period Oct 92-Mar 93		RT Protocol Period July 93-Sept 93		Variance from Base		Savings	
Service Description	Unit Var Cost* ($)	Avg Var Cost ($)	Avg Units	Avg Var Cost ($)	Avg Units	Avg Cost ($)	Avg Units	Cost ($)	Units
O_2 Transport/walk w/O_2	7.72	0.00	0.0	0.03	0.0	(0.03)	0.0	(7.72)	(1.0)
Set up O_2	0.27	0.23	0.9	0.24	0.9	0.00	0.0	(1.19)	(4.4)
Set up (TAG)	5.93	0.00	0.0	0.02	0.0	(0.02)	0.0	(5.93)	(1.0)
Set up (Vent)	11.59	0.00	0.0	0.04	0.0	(0.04)	0.0	(11.59)	(1.0)
Set up (Circuit)	6.74	2.97	0.4	2.05	0.3	0.92	0.1	278.50	41.3
Aerosol-oxygen	0.08	0.00	0.0	0.02	0.3	(0.02)	(0.3)	(6.71)	(83.9)
Apnea alarm monitor	7.99	3.36	0.4	0.42	0.1	2.93	0.4	888.97	111.3
Ventilator hours	7.53	0.30	0.0	0.47	0.1	(0.17)	0.0	(51.81)	(6.9)
Incentive spirometry set up	8.86	5.23	0.6	3.30	0.4	1.92	0.2	582.72	65.8
IPPB treatment	7.57	0.68	0.1	0.32	0.0	0.36	0.0	108.02	14.3
Incentive spirometry/daily	10.00	8.00	0.8	1.35	0.1	6.65	0.7	2,014.00	201.4
Nebulizer treatment	5.97	14.51	2.4	10.44	1.7	4.06	0.7	1,231.55	206.3
Oxygen face mask	0.99	0.00	0.0	0.01	0.0	(0.01)	0.0	(2.97)	(3.0)
Oxygen cannula	0.35	0.10	0.3	0.12	0.3	(0.02)	(0.1)	(6.01)	(17.2)
Pulse oximetry/hr	6.64	0.40	0.1	1.23	0.2	(0.83)	(0.1)	(251.12)	(37.8)
Pulse oximeter	6.05	2.54	0.4	0.16	0.0	2.38	0.4	721.52	119.3
Oxygen hours	0.08	1.28	16.0	1.42	17.8	(0.15)	(1.8)	(44.08)	(551.1)
Chest physical therapy	6.03	0.42	0.1	0.36	0.1	0.06	0.0	19.36	3.2
Service	23.46	0.00	0.0	0.15	0.0	(0.15)	0.0	(46.92)	(2.0)
8 hour CPAP on floors	29.98	0.00	0.0	0.30	0.0	(0.30)	0.0	(89.94)	(3.0)
Totals		$40.01	22.5	$22.46	22.3	$17.55	0.2	$5,318.64	50.5
Total Discharges		645		303					

*Figures have been rounded. Variable unit costs were used to calculate average variable costs of 645 patients during the 6-month base period and for 303 patients during the 3-month pilot study period. Average cost savings variance from the base period was calculated and used to document total cost savings during pilot study.

address any respiratory challenge. If a physician contact was still required beyond the protocol, it was made as a joint effort by the nurse and the RCP. Thus, if we were successful, they were successful. We believe that with this enhanced interaction patient care can only be advanced—a positive consequence of our pilot project.

Possible Modification

Our own cautious approach to implementing the protocols resulted in documentation and patient reassessments during the pilot study that may be excessive for future care. In an attempt to anticipate and respond to every possible respiratory need, we had developed a system that was labor intensive. Although tolerable in use on the single pilot unit, it became clear that the paperwork and patient-reassessment process would have to be streamlined before respiratory protocols could be implemented hospital-wide. We are now actively involved in simplifying the process for the envisioned expansion.

Undertreatment vs Overtreatment

The use of respiratory care protocols is an accepted method of developing clinically effective and fiscally responsible care plans.[14,17] Although the emphasis is often on reduction of therapy, some studies have suggested that patients may also be undertreated.[8,18] Our own data, as shown in Table 3, indicate that utilization of some treatment modalities actually increased during our pilot study. RCPs are well qualified to have a positive impact on clinical resource management in hospitals.[2,4,6,7,9] The ability to effectively assess, initiate timely treatment protocols, and revise the care plan throughout the patient's hospital stay is a valuable skill. Hospitals that choose to utilize RCPs in this fashion may not only reap the financial benefits listed previously but also improve employee satisfaction through enhanced professional standing.

Financial Effectiveness Maintained

The financial effectiveness of the pilot study was demonstrated by a reduction in utilization of respiratory therapy, particularly incentive spirometry and small-volume nebulization—reductions resulting directly from protocol implementation. An additional $5,000 in respiratory cost savings was identified in the 3 months following the pilot study using the same methodology described in Table 3. This suggests that the initial momentum of the project has been maintained. The inability to sustain early success is a potential limitation of any major change. These data also reaffirm that the positive results were not due simply to seasonal differences in demands for respiratory therapy.

Staff Satisfaction

It is unclear at this point whether staff satisfaction has increased as a result of this project. It seems likely that this will occur over time, but the normal frustrations experienced in implementing major change can counterbalance the excitement of a new role. This is a possible short-term limitation that will be monitored through future employee attitude surveys and otherwise unexplained attrition.

Quality Assurance Goals

The quality outcome goals of this project were accomplished as evidenced by similar morbidity and mortality and length-of-stay data as compared to the base period. The RCPs were instructed to err on the side of treating rather than not treating patients whose indications for therapy were questionable. This tended to minimize disagreements with physicians but may have limited the cost savings achieved.

Improved Communication

Improved communication is difficult to measure, but our pilot study clearly increased the frequency and quality of communications of RCPs with physicians and nurses. According to the subjective opinions of the RCPs, relationships have improved with other professionals as a result of the project.

Advice to Would-Be Implementers

Successful implementation of patient assessment-treatment programs depends largely on medical director support. Medical directors can serve as valuable advisors and editors of protocol documents. Also, because they are consumers of the product, they can be effective communicators in ‘selling’ the concept to other physician groups. Clear communication with all personnel involved prior to implementation can assist in overcoming many of the obstacles presented by the process of change.

It is important to remember that an evaluation-treatment program cannot divert a group of employees from being caregivers to being pure evaluators. Such a diversion simply adds to overhead costs and increases bureaucracy. RCPs must become both evaluators and caregivers to be efficient members of the health-care team of the 1990s.

We believe that clinical resource management efforts will be important for successful acute care hospital management over the next few years. The political culture of an institution influences the ease of establishing an evaluation-treatment system. It is reasonable to formulate protocols to be available for implementation when and if incentives (financial or otherwise) develop. It is important to control clinical resources in a palatable manner and to be prepared to reduce staffing should new incentives for dramatic reduction of therapeutic modalities develop rapidly.

A pilot study can be a good way to work through the problems of a new system on a small scale. As a result of the positive results of our study, the Executive Committee of the Medical Staff approved implementation of our assessment-treatment program hospital-wide. Our plans include the development of a plan to bring each nursing unit on line over a period of approximately 6 months. We will then continue to monitor data to identify whether the positive results of our pilot study can be duplicated on a larger scale.

Conclusions

We successfully implemented a pilot patient assessment-treatment program on the orthopedic floor of a large, university-affiliated teaching hospital. Overall utilization of respiratory therapy declined, resulting in a 3-month savings of $5,318. Cost savings during the 3 months following the study were calculated at $5,000, which supports continued financial success. The cost savings associated with this project were accomplished with no adverse effects on quality indicators. The frequency and quality of physician and nurse communication with the RCPs also increased. Data from a successful pilot project can be used as justification for expanding the scope of such programs.

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Simulated Pediatric Cardiopulmonary Resuscitation: Initial Events and Response Times of a Hospital Arrest Team

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BACKGROUND: Cardiopulmonary resuscitation (CPR) training programs exist to enhance knowledge and skills retention. However, they do not ensure that effective CPR will be performed by trainees or resuscitation teams. One aspect of CPR effectiveness is the ability of the team to respond to an emergency call in a timely manner. METHODS: We prospectively evaluated the time required for team members to respond to an emergency call and to initiate definitive treatment in our pediatric facility. The medical staff who responded had no prior knowledge of the simulated cardiac arrest (SCA) events. All events were recorded on audio-cassette tape to determine the sequence of events and response time of arrest team members. SCA scenarios represented examples of cardiac, hematologic, renal, respiratory, and pharmacologic pathophysiology. All participants were instructed to respond as though the SCA were an actual emergency. RESULTS: From December 1991 to January 1993, 37 SCAs were evaluated. Documentation began after a concise arrest scenario had been presented to a designated nursing representative who was to be the first rescuer on the scene. The rescuer first assessed the patient's condition, activated the cardiac arrest system (median elapsed time, MET, 0.50 minutes), and then initiated single-person CPR (MET 0.58 minutes). Administration of oxygen occurred at an MET of 2.25 minutes. The first member of the arrest team to respond was the pediatric resident (MET 3.17 minutes) followed by the respiratory therapist (MET 3.20 minutes), an ICU nurse (MET 3.58 minutes), a pharmacist (MET 3.42 minutes), and anesthesiology personnel (MET 4.70 minutes). DISCUSSION: The use of SCAs (termed "Mega Code") serves as an extension of Basic Life Support and Advanced Cardiac Life Support education and provides a valuable learning experience and quality assurance tool. Limitations that might influence patient outcome during an actual in-hospital arrest have led to refinements in our cardiac arrest procedures. Of particular note was the delay in oxygen administration, which may be linked to its omission from the 1986 and 1992 American Heart Association Basic Life Support Guidelines. CONCLUSION: We believe that BLS education for hospital employees should include and emphasize oxygen delivery for resuscitation. [Respir Care 1994;39(7):725-729.]

Background

The continuous reinforcement of cardiopulmonary resuscitation skills (CPR) and its impact on the retention of knowledge and performance of CPR have been previously reviewed.[1-3] Whereas cardiopulmonary resuscitation training programs (Advanced Cardiac Life Support [ACLS], Pediatric Advanced Life Support [PALS], and Basic Life Support [BLS]) may enhance knowledge retention and performance skills, this does not imply that effective CPR

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will be performed by the arrest team.[2,4] The available data on the outcome of pediatric patients requiring CPR indicates wide variation ranging from 7% to 65% survival.[5-8] These diverse results are probably related to several factors other than the performance of CPR, such as the etiology of the precipitating event (cardiac vs respiratory) and whether survival is characterized as short term (< 24 hours following cardiac arrest), long term (> 24 hours following cardiac arrest), or to hospital discharge.

Whereas cardiac arrest has an acute onset in adults, in pediatric patients it is often preceded by a slow, progressive deterioration of respiratory function.[9] This deterioration in condition frequently results from an unresolved underlying condition such as hypovolemia, sepsis, hypoventilation, metabolic disorder, acidosis, hypoxemia, or irreversible ischemia. Thus, a successful outcome may be influenced by early recognition of clinical antecedents,[10,11] treatment of the underlying condition, and the skills and versatility of the CPR team.

The premise that current standards of basic life support are appropriate for bystander-initiated CPR seems reasonable. However, are current methods of BLS[9] education appropriate for hospital employees who have additional resources available? Because little is known as to what therapies are provided by the first responder during the arrival of the cardiac arrest team, we prospectively evaluated the timeliness of CPR interventions and the response times of the various members of our pediatric CPR team. This review was limited to those events that occurred before and during the arrival of the cardiac arrest team in a series of simulated cardiac arrest (SCA) scenarios of diverse etiology. Any additional activities that occurred during the SCA such as drug calculations, interventional procedures, decision making, deficiency identification, and electrocardiogram interpretation were discussed at length following the completion of each SCA.

Methods

Simulated cardiac arrests were prospectively conducted and evaluated from December 1991 through January 1993 within our 200-bed pediatric teaching hospital. These simulated cardiac arrests (termed "Mega Code") serve as an extension of Basic Life Support and Advanced Cardiac Life Support education.[9,12] The main objectives of SCA are to introduce hospital personnel to a cardiorespiratory arrest situation, identify deficiencies in the current system, reinforce CPR education, and exchange ideas. During these events, a patient history was presented to the initial responders who resuscitated a manikin as though it were a real patient (performed intubation, defibrillation, intravenous infusions, and documentation). Following the completion of the simulated event, individual performance and the performance of the entire cardiac arrest team was evaluated and discussed.

The day of the week, time of occurrence, and location within the 7-floor Maternal Child Health Center and adjoining Children's Hospital were unknown to the participants prior to the call. Variables measured included the time to CPR initiation (assisted ventilation and chest compression), oxygen administration, activation of the cardiac arrest paging system, the arrival of various members of the arrest team, patient connection to an electrocardiogram (ECG) monitor, drug administration, and intubation. Only events that occurred before and during the arrival of the cardiac arrest team to the bedside were reviewed. These variables were selected because the differences in the cardiac arrest scenarios among patient floors (ie, toddlers to young adults) would have confounded the interpretation of any additional measurements. All events were recorded on audio-cassette tape (electrically operated) to accurately document the sequence of events and the median elapsed time (MET) required to respond to the patient described in the scenario. A pediatric resuscitation manikin* and infant intubation head were used to simulate emergency patient conditions. Real-time electrocardiograms were created with an ECG arrhythmia simulator. The ECG tracings were varied according to the scenario or following an intervention initiated by CPR-team members. A primary nurse and two additional nursing participants, appointed by the head nurse of the respective floor, were informed of their participation in the SCA and were given a brief patient history. These scenarios included cases of cardiac disease, hematologic disorders, respiratory pathology, renal pathology, and drug toxicity.

At this hospital, patient location is determined by age and diagnosis. For this reason, scenarios were changed to meet the general diagnosis of patients cared for on the specified floor. Following a brief patient history, the nursing participants were informed that their patient, who was not being electronically monitored and in whom venous access had not been established, was apneic and pulseless, and they were instructed to respond as though this were a true emergency. The medical staff who responded were given the patient history and scenario by the nursing participants. All SCAs occurred during the day shift, and no clinical or mechanical problems were intentionally introduced into the scenario. Emergency equipment and supplies were conveniently located on each wing of the hospital, and mouth-to-mask devices were located in each room. All nursing personnel were BLS certified and were familiar with the use of the mouth-to-mask resuscitation devices.

The pediatric cardiac arrest team at our children's hospital consists of two pediatric residents (one senior resident and one pediatric intensive-care resident), two respiratory therapists, a pediatric intensive care unit nurse, a pharmacist, an anesthesiologist or a nurse anesthetist, and support services personnel. The specific persons assigned to this team vary day to day and shift to shift. All pediatric residents are ACLS certified, whereas respiratory therapists and nurses have completed BLS or ACLS training. The cardiac-arrest team was notified of the emergency via pocket pagers that, when activated, displayed an alpha-numeric description of the floor and room number of the emergency. The nurse (first responder) notified the ward clerk, who called the emergency operator. The operator then activated the cardiac arrest pagers.

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*Suppliers are identified in the Product Sources section at the end of the text.

Guidelines established by the American Heart Association[9,12] were strictly adhered to and were used to evaluate these simulations. The initiation of CPR was defined as performing either assisted ventilation, chest compressions, or both. Data were entered into and analyzed using computer spreadsheet software. Response-time data are reported as the median elapsed time (MET) in minutes, interquartile range (from the first to the third quartile, ie, from the 25th to the 75th percentile), and full range (0th and 100th percentiles).

Results

During this period of review, 37 simulated events were evaluated. Figure 1 gives the METs, interquartile ranges, and full ranges for each event documented. The first decisive actions of the nursing participants were to assess the patient's condition. This assessment frequently consisted of shaking the child and/or talking loudly to the child. Almost simultaneously, the cardiac arrest paging system was activated, and single-person CPR was initiated.

The first members of the cardiac arrest team to arrive were the pediatric residents followed by the respiratory therapist, an ICU nurse, pharmacist, and anesthesiologist or nurse anesthetist. Supporting events occurred in order with oxygen administration, ECG monitoring, endotracheal intubation, and drug delivery by intravenous, intraosseous, or endotracheal route.

Mouth-to-mask resuscitation was administered by nursing personnel in 76% of SCAs (28/37) to provide assisted ventilation. In the remaining instances (9/37), mouth-to-mouth resuscitation was performed. These forms of resuscitation were subsequently replaced by bag-valve-mask ventilation following intubation and/or the arrival of the respiratory therapist.

Discussion

The responsibility for providing interventional or definitive treatment such as the electrical conversion of arrhythmias, vessel cannulation, pharmacologic delivery, endotracheal intubation, and decision making during a cardiac arrest rests primarily with the resident physicians in our children's hospital. The large variation in the response times of individual members of the arrest team is an important finding of these simulated events. In some instances,

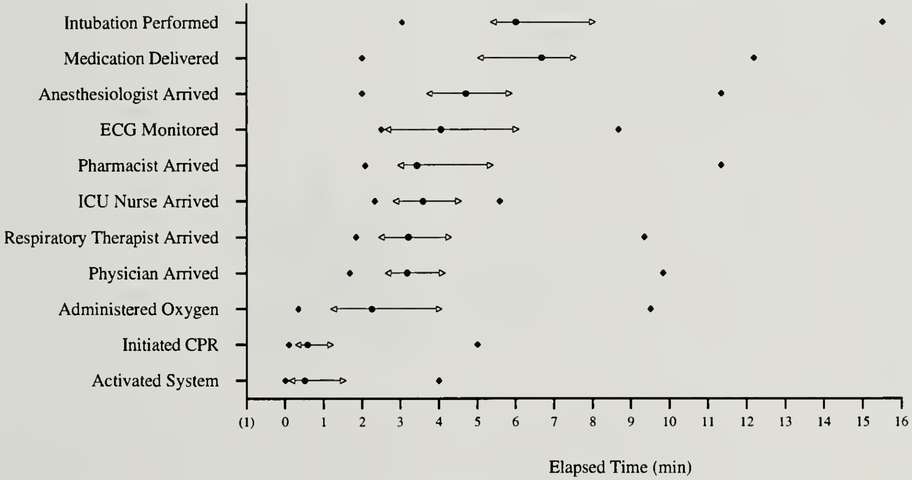

Fig. 1. The time in minutes for the measured events are shown as median (●); interquartile range, from the first to the third quartile (ie, from the 25th to the 75th percentile) (◁—▷); and the full range, from the lowest through the highest value (◆).

failure of the arrest pager to activate may account for the delays, whereas in other instances members of the arrest team were involved in caring for other patients and were unable to respond immediately. Another possible explanation for delay is the understandable reticence of the first responder to rely on the report as given—ie, the patient is apneic and pulseless—and proceeding with an assessment according to BLS guidelines[9,12] rather than immediately activating the cardiac arrest paging system and beginning rescue breathing.

Other issues of concern include the delay in providing oxygen (MET 2.25 minutes) and in the administration of drugs such as epinephrine (MET 6.67 minutes) during these events. Although oxygen (source, flowmeter, and tubing) and a mouth-to-mask device were available at the bedside, a substantial delay—MET 2.25 minutes—was noted in oxygen administration. This delay may be due to a deficiency in 1986 and 1992 BLS algorithms frequently used to in-service hospital employees. These algorithms do not include oxygen administration. The delay in drug administration might be related to the confusion and excitement of the event, delay in the arrival of members of the arrest team, or a delay in establishing a route of administration. However, this is a problem only in patients who do not have established venous access prior to the arrest. These are significant issues because Eisenberg et al[13] demonstrated in adults that the shorter the time interval between patient collapse and the initiation of CPR, the more successful the outcome for out-of-hospital arrests. That study also postulated that a significant relationship exists between long-term outcome and the time from collapse to definitive care. In a study of cardiac dysrhythmias, Walsh and Krongrad[14] found that only 6% of children in cardiopulmonary arrest demonstrated ventricular fibrillation as the terminal rhythm and that only in patients with congenital heart disease. The dysrhythmias that were most strongly associated with cardiopulmonary collapse within the pediatric age group were asystole and idioventricular bradycardia, both commonly resulting from hypoxia.

Whereas cardiac arrest is generally of an acute onset in the adult patient, the occurrence of cardiac arrest in a pediatric patient is often preceded by a progressive deterioration of cardiorespiratory function.[9] This deterioration frequently results from an unresolved underlying condition such as hypovolemia, sepsis, hypoventilation, metabolic disorders, acidosis, or hypoxia. The presenting cardiac rhythm is frequently bradycardia that progresses to asystole. Because of the rapid deterioration that may ensue, it is imperative that airway management and the institution of definitive therapy occur immediately. Interventions known to reverse the primary initiating event or to limit the adverse effects of a secondary phenomenon due to diminished cardiac output include assisted ventilation with supplemental oxygen administration, fluid administration to increase intravascular volume, and electrical conversion of dysrhythmias. In two studies of adult cardiac arrest victims,[10,11] data suggest that clinical deterioration had been documented 6-8 hours before the arrest. In the study by Franklin and Mathew,[10] physicians were either not informed or did not respond appropriately to patients with documented clinical deterioration.

While the observations in our study provide a focal point for discussion, they should be interpreted with caution. A possible limitation of this investigation is the required assumption that an association exists between the responses observed during SCAs and those of an actual cardiac arrest. The potential benefits of this investigation may allow members of the arrest team to adjust their decisions based upon the expected sequence of events and the arrival of essential personnel. In addition, SCAs may be used to review hospital practice, policy, quality assurance documentation, or to redefine individual responsibilities such as allowing the nurse to administer epinephrine before the physician arrives. While the use of SCA has proven to be an effective tool, it has also led to the realization that the most important member of the arrest team is the initial rescuer. Any hesitation by the initial rescuer or a decision to begin treatment before notifying the arrest team may markedly delay their arrival.

The primary objectives of these simulated cardiac arrests are to serve as an adjunct to medical education and to document technical expertise in CPR skills among hospital employees. Our findings are not unique, and are similar to those presented by Sullivan and Guyatt.[3] They reported a response time of 2-3 minutes for their arrest team. In 1974, Ehrlich et al[6] reported that a physician and a nurse were able to reach a cardiac arrest patient within 90 seconds. However, the emergency crash cart took up to 4 minutes to arrive. Twenty years later, with the best efforts and improved technology, in-hospital response times to a critical event have changed little. Although the variation in the response times of members of the arrest team is a longstanding problem, it should be recognized that, in our study, by the time the first member of the arrest team arrived, 3 minutes had elapsed. This is a critical time period during which essential metabolic functions rapidly deteriorate. Even when performed properly, external chest compressions provide only a fraction of the patient's normal cardiac output.[9] It is also recognized that oxygen delivery may be markedly diminished by inadequate pulmonary gas exchange and/or inadequate circulatory volume or function during chest compressions.[9] For these reasons, it seems imperative that oxygen be administered early to prevent profound metabolic acidosis and organ failure.

At present, our hospital is revamping the cardiac arrest system by installing wall-mounted switches that, when pushed, will immediately activate the arrest pagers. This may reduce METs by eliminating the time spent communicating among the nurse, unit clerk, and emergency telephone operator.

Conclusion

The frequent use of simulated cardiac arrests serves as a valuable method to assess the knowledge and performance of medical personnel and to document CPR quality assurance. On the basis of our findings, we have identified a situation that might influence patient outcome during an actual cardiac arrest—delayed administration of oxygen. We applaud and support the recent recommendation of the American Heart Association[15] that administration of oxygen by first responders be emphasized in all BLS courses taught to hospital employees.

PRODUCT SOURCES

Pediatric Resuscitation Manikin:
Laerdal Medical Corp, Armonk NY

Infant Intubation Head:
Armstrong Industries Inc, Northbrook IL

ECG Arrhythmia Simulator:
Armstrong Industries Inc, Northbrook IL

Mouth-to-Mask Devices:
Intertech Resources Inc, Bannockburn IL

Computer Spreadsheet:
Excel version 3.0, Microsoft Corp, Redmond WA

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Prediction and Assessment of Bronchodilator Response in Mechanically Ventilated Patients

Patricia J Wollam RRT, Carol L Kasper RRT, Michael J Bishop MD, and David J Pierson MD

BACKGROUND: Bronchodilators are commonly prescribed for mechanically ventilated patients, yet uniform indications for and objective assessment of the efficacy of aerosolized bronchodilator use in this population are generally lacking. In this prospective study of consecutive mechanically ventilated patients, we asked, Can we identify a priori those patients who are most likely to respond to inhaled bronchodilators? MATERIALS & METHODS: 54 consecutive mechanically ventilated patients in acute respiratory failure participated in the study. We recorded auto-PEEP, PIP, and whether wheezing was present on auscultation before and 15 minutes after the first dose of bronchodilator. Evidence for the presence of reversible airway obstruction (RAO)—diagnosis of COPD or asthma and/or use of inhaled corticosteroids or bronchodilators—was obtained from the patient's chart. The bronchodilator was delivered via metered-dose inhaler with an Aerovent chamber as prescribed by the primary physician. The therapy was deemed indicated if the patient had a history of RAO or if auto-PEEP or wheezing was present. A positive response to bronchodilator was defined as a decrease in wheezing, > 2 cm H_2O decrease in auto-PEEP, or > 4 cm H_2O decrease in PIP. RESULTS: 42/54 (78%) patients had at least one indication for bronchodilator. Of these 42, 27 were positive on at least 1 of the 3 response criteria. Of the 12 patients without an indication, only 1 had a positive response (χ^2, $p < 0.001$). Of the 22 patients who were not wheezing prior to treatment, only 5 showed decreased PIP or auto-PEEP, whereas 23 of 32 who were wheezing responded (χ^2, $p < 0.001$). A presumptive history of RAO was not associated with a bronchodilator response: 9/17 patients with a history of RAO and 18/37 patients with no history of RAO responded (χ^2, $p > 0.05$). CONCLUSIONS: Using the information often available to the clinician (eg, limited patient history, physical exam, PIP, and auto-PEEP), it is not possible to predict reliably which patients will benefit from bronchodilator treatment. Based on the results of this study, we recommend an empirical trial of bronchodilator in mechanically ventilated patients for whom a potential indication exists. In the absence of such an indication or if objective measurements fail to document a response, continued bronchodilator administration may not be clinically useful or cost-effective. [Respir Care 1994;39(7):730-735.]

Background

Bronchodilators are commonly prescribed for intubated, mechanically ventilated patients, although the detection and quantitation of both need and response are much less well defined in this setting than in nonintubated, spontaneously breathing patients.[1-3] Studies have shown that bronchodilator response in intubated patients can be detected by decreases in auto-PEEP and peak inspiratory pressure (PIP).[4,5] These measurements are more readily available at the bedside than quantitation of expiratory flow at a standardized recoil pressure[4,6] and determination of end-expiratory lung volume.[4] In addition, changes in the presence or severity of wheezing on auscultation following bronchodilator administration are commonly accepted

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This study was presented in part by Ms Kasper during the RESPIRATORY CARE OPEN FORUM at the 1993 AARC Annual Meeting in Nashville, Tennessee.

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signs of a favorable response. Despite the availability of these assessments of bronchodilator response, they are not in widespread use by either ordering physicians or those administering the treatments, and aerosol bronchodilators may be prescribed for patients for whom there is no indication and who do not benefit from their use. Such indiscriminate use of bronchodilators might result in significant unnecessary costs. If so, a substantial cost-savings would result if in fact a group of patients that are unlikely to benefit can be identified a priori.

We hypothesized that inhaled bronchodilators would not result in objective evidence of patient improvement unless a traditional indication for therapy was present (ie, the patient had evidence of either increased resistance—wheezing or auto-PEEP—or a history of reversible airway obstruction [RAO]).

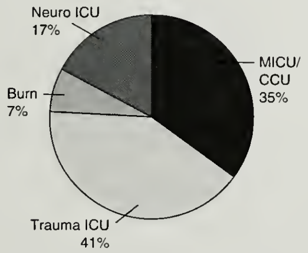

Fig. 1. Breakdown of patient population used in study.

Materials & Methods

Our patient population consisted of 54 consecutive mechanically ventilated patients with acute respiratory failure (41 male and 13 female, mean age 51.3 years, age range 3-98 years) admitted to the surgical/trauma (22), medical/coronary (19), burn (4), and neurosurgery (9) intensive care units (Fig. 1). Patients were studied before and after the first bronchodilator treatment was administered while intubated.

After patients had received orders for bronchodilators and prior to their first treatment, our therapists recorded initial ventilatory parameters of PIP, auto-PEEP, and the presence of wheezing on auscultation. The bronchodilator (dose determined by the primary physician) was then administered by metered-dose inhaler* with a collapsible spacer, placed at the patient-Y (Fig. 2). The metered-dose inhaler was actuated at end-exhalation so the medication was given during the next inspiration—one puff per breath until the prescribed dose was delivered (Table 1). Fifteen minutes after bronchodilator administration, the ventilatory parameters were recorded again. All patients were ventilated in the assist/control or synchronized intermittent mandatory ventilation mode using a square-wave flow pattern. Auto-PEEP was measured using the expiratory hold method at the beginning of the next mechanical breath on all patients who were not spontaneously breathing. In those who had spontaneous breaths, auto-PEEP could not be measured reliably, and, therefore, the measurement was omitted on those patients. Auscultation was done independently by the patient's nurse (RN) and the respiratory care practitioner (RCP), and each recorded whether wheezing was present. Following the bronchodilator treatment, both the RN and RCP independently evaluated whether wheezing was unchanged, increased, or decreased.

In testing our hypothesis that patients without a conventional indication for bronchodilator therapy would not respond, we considered the following as acceptable indications for bronchodilator therapy: (1) a possible history of reversible airway obstruction from information in the patient's chart (diagnosis of COPD or asthma, previous use of inhaled corticosteroids or bronchodilators), (2) the pres-

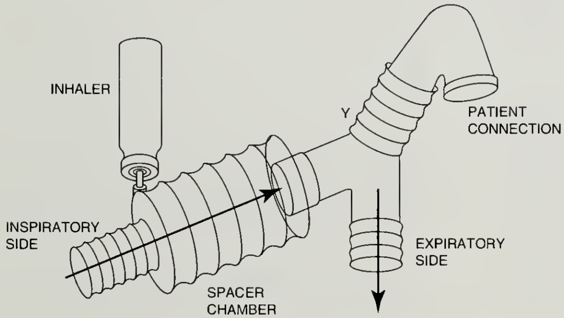

Fig. 2. Placement of metered-dose inhaler and spacer chamber in ventilator circuit.

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* Manufacturers and suppliers are identified in the Product Sources section at the end of the text.

Table 1. Dose of Bronchodilator Ordered by the Attending Physicians for the 54 Patients in Our Study

n	Albuterol Sulfate (puffs)	Ipratropium Bromide (puffs)
7	20	20
5	10	10
2	6	
9	10	
31	20	

ence of auto-PEEP, and (3) the presence of wheezing. A positive response to bronchodilator therapy was defined as a > 2 cm H_2O [0.2 kPa] decrease in auto-PEEP, a > 4 cm H_2O [0.4 kPa] decrease in PIP, or a decrease in wheezing. If wheezing was judged subjectively to be decreased by either RN or RCP, it was recorded as decreased. We tested our hypotheses using chi-square tests for association.[7]

Results

The presence of one of our indications for bronchodilator therapy was strongly associated with a positive response (χ^2, $p < 0.001$, Fig. 3A). Forty-two of 54 patients (78%) had at least one indication for the bronchodilator therapy, 17 patients had a positive history, 17 had auto-PEEP prior to bronchodilator administration, and 32 had wheezing. Of the 12 patients without an indication, only 1 (8%) met a response criterion. Of the 42 patients with at least one indication, 27 (64%) met at least 1 of the 3 response criteria (wheezing decreased in 23, auto-PEEP decreased > 2 cm H_2O in 6, and PIP fell > 4 cm H_2O in 15). The presence of wheezing prior to treatment was strongly associated with a positive response to bronchodilator (χ^2, $p < 0.001$, Fig. 3B). Of the 22 patients who were not wheezing prior to treatment, only 5 (23%) showed a decrease in PIP or auto-PEEP, whereas 23 of the 32 (72%) who were wheezing met at least one of the response criteria. A presumptive history of RAO was not associated with a bronchodilator response (χ^2, $p > 0.05$, Fig. 3C). Nine of the 17 (53%) patients who had a positive history of RAO and 18/37 (49%) with a negative history responded to administration of a bronchodilator.

Discussion

As we had hypothesized, patients who had no prior history of RAO and no auto-PEEP or wheezing had no change in PIP. Among patients who had some history or evidence of airway obstruction, 64% showed some response. Within the group with some indication for bronchodilators, the presence of wheezing on auscultation prior to treatment was associated with a positive response, but historical information available from the patient's chart at the time of initiation of therapy was poorly associated with

Bronchodilator Indicated?

Patient Responded?	Yes	No	
Yes	27	1	28
No	15	11	26
	42	12	54

$\chi^2 = [(27)(11)]/[(1)(15)] \approx 19.0$; $p < 0.001$

Conclusion: There is a significant association between the absence of indications for and nonresponse to inhaled bronchodilators for patients who require mechanical venti-

Wheezing Present?

Patient Responded?	Yes	No	
Yes	23	5	28
No	9	17	26
	32	22	54

$\chi^2 = [(23)(17)]/[(5)(9)] \approx 11.0$; $p < 0.001$

Conclusion: There is a significant association between the presence of wheezing and response to inhaled bronchodilators for patients who require mechanical ventilation.

History of RAO?

Patient Responded?	Yes	No	
Yes	9	18	27
No	8	19	27
	17	37	54

$\chi^2 = [(9)(19)]/[(18)(8)] \approx 1.2$; $p > 0.05$

Conclusion: A history of RAO is not significantly associated with a response to inhaled bronchodilators for patients who require mechanical ventilation.

Fig. 3. Two-by-two data tables and chi-square statistics for bronchodilator indications, presence of wheezing, or history of RAO and patient response.

a positive response to bronchodilators. Our thresholds for a positive response (decrease of auto-PEEP of > 2 cm H_2O and decrease of PIP of > 4 cm H_2O) were based on our observation that in non-paralyzed patients, a variation of 1-3 cm H_2O in PIP is commonly seen. In our study, a retrospective analysis of the patients without an indication for bronchodilators revealed no patient with a PIP decrease > 2 cm H_2O.

Our results should be interpreted with caution. We studied only the first bronchodilator treatment in our patients. It may be that patients who failed to demonstrate a response would have done so after subsequent treatments. We studied the response to the doses of inhaled bronchodilator that our patients' primary physicians had ordered. It is possible that larger doses would have produced a detectable response. However, the doses used were in keeping with current recommendations[1,8] and with consideration for the small fraction of the total dose that is delivered to the patient via an endotracheal tube.[9-13] Our data attest to the potential for a positive response using these doses.

It is possible that a different delivery technique (eg, a jet nebulizer) would have produced a detectable response when the metered-dose inhaler did not. However, several well-done studies have failed to show any inherent superiority of nebulizers to metered-dose inhaler delivery in intubated patients if appropriate doses of the latter are used.[1,14,15]

It is unlikely that placing the spacer device elsewhere in the ventilator circuit would have produced better results because prior work showed little difference between placing the spacer between the endotracheal tube and patient circuit and in the inspiratory limb at the Y-connector.[16] Rau et al[16] also showed that significantly more drug was delivered with the spacer method when compared to an MDI actuator/adapter at the ETT.

Our study contrasts with a recent study by Manthous et al[17] who found that no improvement could be detected when MDIs were used, even up to 100 puffs of bronchodilator. That study may have been flawed due to the elbow-type actuator/adapter used. Elbow actuator/adapters deliver significantly less drug than do spacer devices.[18,19]

It is possible that a more detailed medical history or results of prior pulmonary function tests would have enabled us to predict which patients would respond. We deliberately restricted ourselves to the information typically available to the RCP administering aerosol therapy to recently intubated patients—physicial assessment, information in the medical record (such as diagnosis), and personal knowledge of the patient. Such patients are usually unable to give a more detailed history themselves, and family members are often unavailable.

Patients with COPD may or may not demonstrate a reversible component to their airflow limitation when they are acutely ill, and this may correlate poorly with bronchodilator responsiveness determined in the laboratory during a period of clinical stability. Many of these patients may have received multiple doses of bronchodilators prior to intubation and may have already reached a maximal response. We do not recommend that bronchodilator therapy be discontinued in patients with asthma or COPD who have previously shown a favorable response to bronchodilators, even if bronchospasm was not the reason for intubation, and even if they do not initially respond according to the measures used in this study.

Despite these limitations, our study supports the observation that aerosolized bronchodilators are frequently administered to patients who are unlikely to benefit from this therapy. When bronchodilators are prescribed for patients who do not have an obvious indication, we recommend empirical trials of therapy, and if there is no detectable response, continuation of the therapy may not be warranted.

Whereas the adverse effects of unnecessary doses of bronchodilators are minimal, the costs are not. We obtained the billing records of 11 of the 12 patients in this study who had none of our 3 indications for therapy. Because actual costs may be more relevant than patient charges, we also calculated the actual costs to the hospital. This was done using a therapist-time unit for each treatment of 15 minutes, an entry-level therapist hourly wage, and the cost of albuterol ($5.97/MDI cannister) and ipratropium bromide ($21.78/MDI cannister) to the hospital. However, these costs underestimate the total cost of therapy because other hospital costs like overhead and benefit adjustments to wages were omitted. The costs and charges for aerosolized bronchodilator therapy while these patients were intubated are shown in Table 2. In one instance (Patient 1) the total hospital charges exceeded $4,000. In patients who have no indication for therapy, significant-cost-savings may be realized by empirically stopping the therapy. If no detectable response is seen in such patients, it would be reasonable to withhold further bronchodilator treatments unless objective evidence of RAO emerges.

Fifteen of our patients had at least one indication but showed no detectable bronchodilator response after the first dose of medication. If we assume that this lack of response would have persisted after subsequent doses, it may be that further cost-savings would have been possible by stopping the therapy.

Table 2. Charges Generated for Bronchodilator Administration in 11 Patients with No Indicators for This Therapy as Used in This Study*

Patient	Number of Treatments	Number of Puffs per Treatment	Total Cost of Albuterol ($)†	Total Cost of Ipratropium Bromide ($)‡	Total Cost of Therapist Time ($)	Direct Total Charges ($)	Hospital Costs ($)§
1	253	20	216.30	512.40	4,048.00	4,776.70	1,426.51
2	170	20	144.20		2,720.00	2,864.20	656.50
3	15	20	20.60		240.00	260.60	61.97
4	26	10	20.60	48.80	416.00	485.40	61.97
5	10	10	10.30		160.00	170.30	39.32
6	163	20	144.20	414.80	2,608.00	3,167.00	997.45
7	2	20	10.30		32.00	42.30	12.64
8	1	20	10.30	24.40	16.00	50.70	31.09
9	3	20	10.30		48.00	58.30	15.98
10	12	20	10.30		192.00	202.30	45.99
11	5	20	10.30		80.00	90.30	22.65
Total	660	200	607.70	756.40	10,560.00	12,168.10	3,452.31
Mean	60	18	55.20	189.10	960.00	1,106.19	313.85

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*Source: Actual billed charges from patient billing records.

†Albuterol cannister contains 240 puffs/cannister @ billed cost of $10.30 ea.

‡Ipratropium bromide cannister contains 200 puffs/cannister @ billed cost of $24.40 ea.

§Derived from 15 min therapist time unit, an entry-level therapist wage, and the cost of albuterol ($5.97 ea) and ipratropium bromide ($21.78 ea) to the hospital. Indirect costs and overhead are not included.

Conclusions

The assessments used in this study to detect a favorable response (a decrease in wheezing, PIP, or auto-PEEP) are noninvasive and generate little extra cost. Because we found a significant association between these indices and the patients' response to bronchodilators, their routine use in mechanically ventilated patients for whom bronchodilator therapy has been ordered could lead not only to more appropriate allocation of bronchodilator therapy but also to marked reductions in the cost of ICU care for these patients.

ACKNOWLEDGMENTS

We thank the Respiratory Care Staff of Harborview Medical Center for assistance with the data collection and Peggie Griffith for her help with preparation of the manuscript.

PRODUCT SOURCES

Ventilators:

Siemens Servo 900C, Siemens Medical Systems, Danvers MA
Hamilton Veolar, Hamilton Medical, Reno NV

Bronchodilators:

Albuterol sulfate, Ventolin, Allen & Hanburys, Research Triangle Park, NC
Ipratropium bromide, Atrovent, Boehringer Ingelheim Pharmaceuticals Inc, Ridgefield CT

Spacer:

AeroVent, Monaghan Medical Corp, Plattsburgh NY

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Noninvasive Positive Pressure Ventilation in End-Stage Cystic Fibrosis: A Report of Seven Cases

Raj Padman MD, Vinay M Nadkarni MD, Susan Von Nessen MSN, and John Goodill MD

Noninvasive positive pressure ventilation (NIPPV) by nasal mask has been successfully applied to the management of patients with chronic hypercapnic respiratory failure and to patients with neuromuscular disease. Although pediatric and young adult cystic fibrosis (CF) patients with end-stage disease exhibit abnormal gas exchange while awake and further derangement in gas exchange during rapid eye movement sleep, little has been reported on results of NIPPV in such patients. We report our experience with 7 CF patients (age 9-30 years) in whom clinically important derangements in gas exchange were present despite conventional therapy. Application of nocturnal nasal bi-level intermittent positive pressure ventilation (BiPAP™) was well tolerated, improved respiratory acidosis and the subjective sensation of dyspnea, and was associated with decline in respiratory rates and improved quality of sleep and capacity to perform activities of daily living. On the basis of our experience, we believe that nocturnal NIPPV may be effective as a bridge between worsening of ventilation and transplantation for pediatric and young adult patients with cystic fibrosis. [Respir Care 1994;39(7):736-739.]

Introduction

Heart-lung transplantation for patients with end-stage cystic fibrosis (CF) is becoming established.[1,2] The results are encouraging and compare favorably with results in patients without CF who undergo heart-lung transplantation.[3,4] Positive pressure ventilation applied noninvasively (NIPPV) with a nasal mask has been utilized successfully both in acute and chronic respiratory failure of various etiologies.[5-10] We have previously reported success with this treatment modality in pediatric neuromuscular patients with both acute and chronic respiratory insufficiency.[11] Because of our previous experience with both negative pressure ventilation and bi-level positive airway pressure ventilation, we decided to offer NIPPV via BiPAP™ (Respironics Inc, Murrysville PA) when we are faced with end-stage CF patients who are awaiting lung transplantation. NIPPV appears to offer a less cumbersome, less labor-intensive method of supporting gas exchange that also allows patient mobility until a transplant organ becomes available. Nocturnal NIPPV stabilizes adult patients with CF and hypercapnic respiratory failure.[6] The beneficial effects of this treatment modality for end-stage CF patients with impaired gas exchange who await lung transplantation are just beginning to be explored.[2]

We report our experience with NIPPV management of seven pediatric and young adult CF patients.

Methods

Candidates for NIPPV were CF patients whose diagnosis had been confirmed by two positive sweat tests and who were considered to have end-stage disease and to be candidates for lung transplantation ($FEV_1 \leq 30\%$ in boys and men and $\leq 35\%$ in girls and women). They had developed symptoms and signs of chronic hypercapnic respiratory failure and derangement in gas exchange documented on arterial blood gases by hypoxemia ($P_{aO_2} < 60$ torr) and hypercarbia ($P_{aCO_2} \geq 55$ torr). All patients were admitted to the hospital and begun on standard treatment for complications associated with CF,[12] including intravenous antibiotics, bronchodilator aerosol treatments, chest physical therapy, and nutritional assessment and supplementation.

Since December 1990, ventilation by BiPAP™ has been approved for use as a supportive modality at the

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Alfred I duPont Institute for pediatric patients with chronic respiratory failure who suffer an acute or progressive deterioration in gas exchange, with the goal of avoiding short- and potentially long-term ventilation with an artificial airway. Informed consent/assent for NIPPV was obtained for all patients and was initiated on the pediatric general care floor. All patients were monitored continuously by pulse oximetry. The nasal mask was gently introduced over the nasal bridge, initially with no flow. NIPPV in spontaneous mode was initiated with peak inspiratory pressure (PIP, or IPAP) at 5 cm H_2O and positive end-expiratory pressure (PEEP, or EPAP) at 3 cm H_2O, and adjusted as needed in 2-cm H_2O increments, guided by clinical assessment of patient comfort, breathing pattern, breath sounds and chest excursion, and pulse oximeter monitoring of oxygenation. In patients with acute exacerbations, NIPPV was used continuously for 72 hours. In patients with chronic stable respiratory acidosis, NIPPV was used nocturnally for 6 to 10 hours/night for as long as 15 months.

Subjective assessments made prior to and after initiation of NIPPV included determination of degree of dyspnea, activity tolerance (bedbound, activities of daily living, school), sleep pattern (restless, comfortable, daytime somnolence), morning headache frequency, work of breathing (heart rate, respiratory rate, accessory muscle use), and need for supplemental oxygen ($S_{pO_2} \approx 93\%$). Objective assessments of pulmonary function, gas exchange, plasma bicarbonate pool, and outcome were obtained by chart review and follow-up visits. Statistical analysis of pre- and post-treatment ventilatory variables were assessed using paired *t* test for differences in P_{CO_2}, HCO_3^-, and respiratory rates. Results are presented as mean ± standard deviation and standard error of mean.

Results

From 1990 through 1993, seven patients with end-stage CF (ages 9-30 years, male-female ratio 2:5) were noninvasively ventilated. Five patients were enlisted while awaiting lung transplantation and two patients during acute respiratory deterioration. The objective and subjective clinical characteristics of these patients in relation to NIPPV use are reported in Figure 1 and Table 1.

All patients had clinically important derangement in gas exchange that persisted despite conventional therapy with appropriate antibiotics (determined by sensitivity of *Pseudomonas* and *Staphylococcus* species), bronchodilator aerosol therapy, chest physical therapy, and nutritional support. NIPPV with mean (SD) inspiratory pressure 10 (3.7) and mean (SD) expiratory pressure 3.4 (1.3) was utilized for up to 72 hours continuously and was thereafter converted to primarily nocturnal use to combat chronic respiratory acidosis.

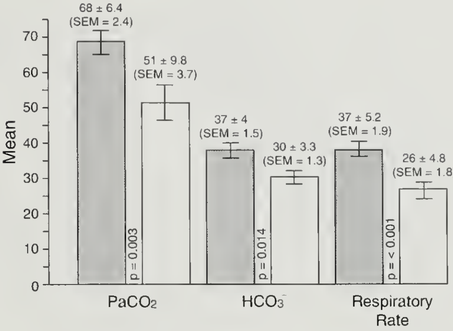

Fig. 1. Values are mean ± standard deviation (SD) and bars are mean ± standard error of the mean (SEM) values for P_{aCO_2}, HCO_3^-, and respiratory rate in 7 patients with end-stage cystic fibrosis, before ▨ and after ☐ periods of noninvasive positive pressure ventilation by nasal mask.

Each patient tolerated NIPPV well and demonstrated improvement in ventilation documented by a clinically important decline in P_{aCO_2}, serum bicarbonate concentrations, and respiratory rates as depicted in Figure 1. There was relief of severe dyspnea with decline in respiratory rates, improvement in ventilation, less use of accessory muscles, subjective improvement in headache frequency and sleep pattern, and improvement in performance of daily activities. In patients with chronic respiratory acidosis, NIPPV was used nocturnally and allowed a near-normal daytime lifestyle, with resolution of acidosis. Patients were cared for in a nonintensive care unit setting.

They maintained the ability to ambulate, communicate, and eat and drink normally. None required an indwelling airway or pharmacologic sedation. The total number of hospital days/month in the year prior to NIPPV compared with days/month after institution of NIPPV and before transplant was 6.9 days vs 1.8 days/month/patient. In five patients, NIPPV acted as a bridge to transplantation, sustaining life from 3 weeks to 15 months. Two patients died while being supported by NIPPV for acute exacerbations. NIPPV was used from 3 weeks to 15 months in Patients 1 through 5 while they awaited donor organs. Of the 5 patients, 4 patients had successful transplants and 1 patient died after 15 months of NIPPV, before a donor organ could be obtained. NIPPV maintained a near-normal quality of life for these patients.

We reviewed retrospectively the pulmonary function tests of the 5 patients in whom results were available. Some improvement was noted in only 2 of these (5%, Patient 5; 17%, Patient 1). The others had the progressive decline seen routinely in CF patients with end-stage disease.

Table 1. Variables in Seven End-Stage Cystic Fibrosis Patients before and after Noninvasive Positive Pressure Ventilation

Variable	Patient 1		Patient 2		Patient 3		Patient 4		Patient 5		Patient 6		Patient 7	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Dyspnea	+	—	+	—	+	—	+	—	+	—	+	—	+	—
Accessory muscle use	+	—	++	—	++	+	++	+	++	+	++	+	++	+
Respiratory rate	32	20	34	24	48	32	36	22	36	24	36	28	38	32
Sternal retractions?	+	—	++	+	++	+	+	+	++	+	+	—	+	—
Bedbound?	+	—	+	—	+	+	+	—	+	—	+	+	+	+
$S_{pO_2} \leq 93\%$	+	—	+	—	+	+	+	—	+	—	+	—	+	+
Supplemental O_2 (L/min)	5	0	4.5	0.5	2.5	2.5	4	2	3	5	3	3	0.5	2
Transplant?	Yes, after 5 months		Yes, after 10 months		Yes, after 3 weeks		No, awaited donor organ for 15 months		Yes, after 10 months		Delivered baby, awake, able to hold infant & interact with family		NL	
Days to hospital discharge (time)	133 (5 mo)	9	80	33	113	21	60	12	30	0	NA (expired)		NA (expired)	

+ = moderate; ++ = severe; — = absent.
NA = not applicable; NL = not used.

Discussion

The use of conventional mechanical ventilation with placement of an invasive artificial airway (eg, endotracheal or tracheostomy tube) is not without risk in patients frequently infected with gram-negative organisms who have severe airflow obstruction. Mechanically ventilated CF patients have a prolonged postoperative course.[1] Negative pressure devices have a number of limitations, including bulk, difficulty in fit, patient discomfort, promotion of vocal cord closure, and upper airway obstruction.[3,13,14]

During nasal NIPPV, spontaneous inspiratory effort is reduced.[15] In theory, respiratory muscle energy expenditure and work of breathing are also decreased. Improvement in respiratory muscle strength, cough efficacy, and clearing of secretions has been reported in CF patients on NIPPV,[7] although nasal PPV has been shown to be less effective in kyphoscoliosis patients particularly those with severe hypercapnia.[16] All of our patients had documented hypercapnia, which improved with NIPPV. None of our patients exhibited any complications related to skin breakdown over the nasal bridge or complications related to barotrauma. None of our patients experienced hypotension or pneumothorax, which are potential complications of positive pressure ventilation especially if IPAP is ≈ 20 cm H_2O.[17] In patients with emphysematous blebs, great caution and careful surveillance for pneumothorax should be maintained even with lower pressures.

Although we did not study the cost-effectiveness of NIPPV relative to conventional ventilation for end-stage CF, we believe it to be cost-effective because it can be maintained in the home, precluding the ongoing utilization of expensive hospital and intensive care resources that are usually associated with tracheostomy and mechanical ventilation. NIPPV improves patient comfort, decreases the need for ancillary care, and is without the physical and psychological trauma associated with tracheal cannulation and ventilation. In CF patients with acute exacerbations marked by pulmonary deterioration who have not already enlisted for organ transplantation, use of noninvasive ventilatory modes may allow palliation until enlistment and organ procurement issues can be resolved. Whether NIPPV will facilitate recovery from acute exacerbations in CF patients with advanced disease requires further prospective study. NIPPV used perioperatively during transplant may decrease morbidity. In addition, whether this treatment modality will retard deterioration in lung function in patients with advanced CF is yet to be determined.

A prospective, randomized, controlled study is needed to determine the ability of NIPPV to retard deterioration of lung function, to provide support during the perioperative period of heart-lung transplantation, and to support CF patients with acute exacerbations. The prospects for respiratory muscle rest, caloric conservation, and improved gas exchange without the prolonged need for an indwelling artificial airway are encouraging.

Conclusion

We believe that our report is the first involving NIPPV for pediatric and young adult CF patients. In end-stage pediatric and young adult CF patients with significantly impaired gas exchange awaiting lung transplantation, application of nasal-mask NIPPV improved oxygenation, ventilation, chronic respiratory acidosis, subjective sensation of dyspnea, quality of sleep, and capacity to perform activities of daily living. It sustained life while patients awaited lung transplant for periods of 3 weeks to 15 months. These benefits were attained in the general care hospital environment rather than in the intensive care unit. Additional prospective, controlled, and randomized studies are needed to confirm the beneficial use of this treatment in CF patients during acute exacerbations and in patients with end-stage disease awaiting lung transplantation.

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One Respiratory Care Department's Contribution to the 'Bottom Line'

L Lynn LeBouef BS RCP RRT

BACKGROUND: Although many hospital departments that were revenue producers have become cost centers and revenues above expenditures have shrunk, some departments continue to contribute. METHODS: I analyzed the financial statements of our 240-bed, not-for-profit hospital to determine the Respiratory Care Department's actual contribution to the hospital's 'bottom line' (ie, revenue above expenditures). The Respiratory Care Department's financial statement, the Hospital's profit and loss statement, and the financial statements for all 54 hospital departments were reviewed. RESULTS: Analysis revealed that the Respiratory Care Department's revenue dollar contributed $0.095 to the hospital bottom line for each revenue dollar generated. Analysis also demonstrated that the break-even contribution margin for revenue departments was 76.77%. Departments with contribution margins greater than 76.77% were revenue contributors and those departments with less than 76.77% were cost centers. CONCLUSIONS: The Respiratory Care Department was the hospital's largest revenue contributor, generating 42.8% of the hospital's revenue above expenditures. In today's health-care environment, it is sound fiscal reasoning to control cost and to strengthen those departments and services that are responsible for the financial viability of the institution. The results of this study show that our Respiratory Care Department has assumed the leadership role in the economic viability of our hospital and is its most cost-efficient contributor to health care. [Respir Care 1994;39(7):740-745.]

Background

For the past 10 years, hospital executives and department managers have struggled with the reality of traditional revenue-producing departments' becoming cost centers.[1] Hospitals have watched their 'bottom line' (ie, revenue above expenditures) shrink to an average of 2-3% of revenue generated as illustrated in Figure 1.[2] Although we have watched hospital net revenue decrease, it makes sense that the bottom line is being generated by some source or sources within the institution. It was with this in mind that I undertook an analysis of the Respiratory Care Department of our 240-bed, not-for-profit hospital and quantitated the Department's contribution to the Hospital's revenue above expenditures.

Methods

Three documents were obtained from the institution and studied for the financial analysis:[3] (1) the 1993 Financial Statement for the Respiratory Care Department for fiscal year ending June 30, 1993; (2) the Profit & Loss

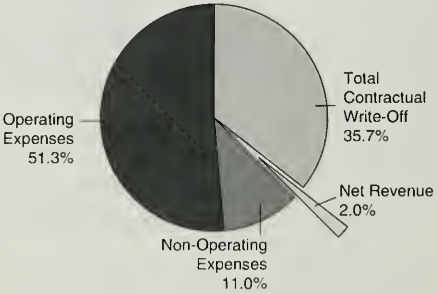

Fig. 1. Typical allocation of hospital revenue.

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Statement (P & L) for the Hospital for the fiscal year ending June 30, 1993; and (3) the 1993 financial statements of all hospital departments for the fiscal year ending June 30, 1993. For simplicity, revenue was factored to become $1.00. All expenses were factored to become a percentage of each revenue dollar generated.

The Respiratory Care Department and its associated department-controlled expenses were reviewed first. Department-controlled expenses were defined as those expenses directly related to the operation of the Respiratory Care Department (eg, salaries and wages, departmental supplies, equipment rental, and repair and maintenance).

The Hospital's P & L was then reviewed to determine contractual and other deductions from revenue and those operational expenses that were associated with the general operation of the hospital. The term operational expenses was defined as those expenses that were not department-specific that were incurred by the hospital in normal day-to-day operation of the institution and not already included in individual departmental financial statements (eg, employee benefits, collection and legal fees, general and malpractice insurance, public relations costs, utilities, physician recruitment expense, JCAHO compliance expenses, postage, accounting fees, and costs of utilization review). These expenses generally fell under the budget heading of Administrative Services but had hospital-wide rather than department-specific implications.

The Hospital's P & L was also reviewed for those nonoperational expenses that were not associated with the general operation of the hospital. Nonoperational expenses were defined as those expenses associated with depreciation, amortization, and interest paid to retire hospital bonds.

The financial statements of all 54 hospital departments were then reviewed to determine those departments that could be classified as revenue-producing and those that could not. Revenue-producing departments are allowed to stand on their own in regard to profitability and their associated expenses. However, revenue-producing departments must generate the revenue to pay the associated expenses from departments that do not produce revenue. Eighteen departments that do not produce revenue were identified from their financial statements. All revenue-producing departments were evaluated to determine their relative contributions to the hospital's revenue above expenses.

Results

Respiratory Care Department

The Respiratory Care Department's financial statement for fiscal 1993 revealed a gross revenue of $6,174,638 with associated "department-controlled" expenses of $846,614 or 13.7% of each revenue dollar generated. A breakdown of these department-controlled expenses is shown in Figure 2. Gross revenue was then factored to be equal to $1.00 with the associated expenses factored to be equal to $0.137, yielding a contribution margin of 86.3% as shown in Figure 3A. Therefore, for every dollar that this Respiratory Care Department generates, it spends $0.137 on the functional operation of the department and contributes $0.863 cents to the hospital for use in covering other hospital expenses.

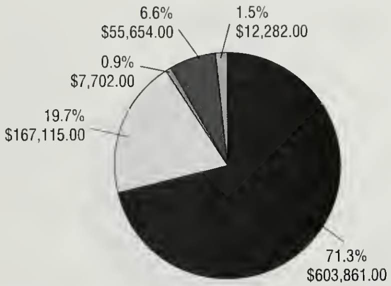

Fig. 2. Results of analysis of Respiratory Care Department-controlled expenses. ■ = salary and wages; ▩ = supplies; □ = other; ■ = equipment rental; ▨ = repair and maintenance.

It should be noted that, although the Respiratory Care Department was the focus of this study, any revenue-producing department could be inserted into the model at this point to determine its profitability and contribution. The other expenses, categorized below, are hospital-wide expenses, and the same deductions from revenue would apply to all revenue-producing departments.

Contractual Deductions from Revenue

The Hospital P & L for fiscal 1993 was reviewed for contractual write-offs and other deductions from revenue. Actual contractual deductions were factored as a percentage of gross hospital revenue from the P & L and are shown in Table 1. Example: Gross hospital revenue was determined to be $68,813,699 with a Medicare contractual write-off agreement of $16,769,496. Dividing the amount of the Medicare write-off by the gross revenue revealed that 24.3% of each revenue dollar generated was written off to Medicare. The same was done with the other contractual- and revenue-deduction categories of the P & L. This showed a total deduction from revenue, including contractual, of 35.7% of each revenue dollar generated. When this $0.357 in contractual write-off is combined with the $0.137 in Respiratory Care Department expense, the Respiratory Care revenue dollar is now worth $0.506 as illustrated in Figure 3B.

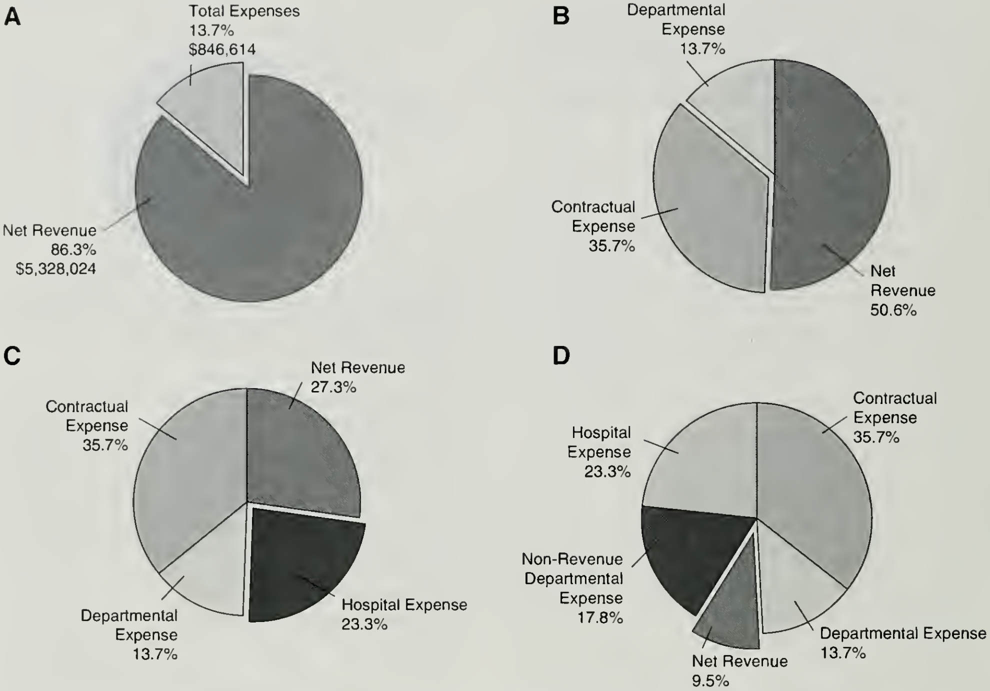

Fig. 3. ▩ = net revenue; □ = departmental expense; ▒ = contractual expense; ■ = hospital expense; □ = expense from departments not producing revenue. A. Breakdown of department-controlled expenses vs revenue for the Respiratory Care Department. B. Effect of contractual deductions and department expense on Respiratory Care Department's revenue. C. Impact of hospital-wide expense on Respiratory Care's revenue dollar. D. Net revenue from Respiratory Care's revenue dollar after all expenses were deducted.

Table 1. Contractual Deductions from Revenue

Contractual Source	Deduction Percent (of total revenue)
Medicare	24.3%
Medicaid	1.9%
Blue Cross	0.9%
Doubtful accounts	3.7%
Charity	0.7%
Workman's Compensation	0.2%
PPO* discounts	3.5%
Courtesy write-off	0.5%
Total Contractual Deduction	35.7%

*PPO = preferred provider organization.

Operational Expense

It was noted in the P & L that employee benefits were not assigned to the individual departments in which they were incurred but rather were grouped into an operational-expense category of the hospital as a whole. The largest costs associated with employee benefits are group medical insurance and the employer's contribution to the employee pension plan. Other benefit expense included unemployment tax, worker's compensation insurance, and other miscellaneous benefits. Total cost of employee benefits was calculated to be 4.24% of each revenue dollar generated (Table 2).

Other operational expenses totaling 7.84% of each revenue dollar generated were noted from the P & L. These expenses, in descending order of expense, included utilities, physician recruitment and advertising, malpractice insurance, general insurance, accounting and legal fees associated with external financial audits and general legal issues, collection cost, public relations, postage, JCAHO expense, bond trustee expense, board-of-directors expense, credit card commission, external utilization review, ambulance services, and other miscellaneous expenses associated with the day-to-day operation of the institution. This expense category is also noted in Table 2.

Nonoperational Expense

I also noted on the P & L a separate category for nonoperational expense. This expense was split into (1) interest expense and (2) depreciation and amortization. The interest expense was the expense incurred to retire hospital bonds issued to finance construction. Depreciation and amortization are part of the normal accounting procedure and are self-explanatory. Interest expense was found to be 5.62% of each revenue dollar generated. Depreciation and amortization were determined to be 5.6%. Total nonoperating expense was therefore 11.22% of each revenue dollar generated, as noted in Table 2.

Table 2. Total Hospital-Wide Expense: Percentage of Each Revenue Dollar Generated

Expense Category	Percent of Revenue
Employee benefits	4.24%
Other expenses	7.84%
Nonoperating expenses	11.22%
Total Hospital Expense	23.3%

When the $0.233 in total operating and nonoperating expense (Table 2) is added to the $0.357 in contractual deductions and the $0.137 in Respiratory Care Department expense, the Respiratory Care revenue dollar is now worth $0.273 cents as illustrated in Figure 3C.

Expenses of Departments Not Producing Revenue

Salaries, departmental supplies, purchased services, and equipment rental have not been considered as hospital expenses except for those expenses incurred by the Respiratory Care Department and listed on its financial statement as shown in Figure 2. This was done to allow each revenue-producing department to be evaluated on the basis of the individual expenses incurred by that department. However, revenue-producing departments must generate the revenue to cover expenses of departments that do not produce revenue.

The financial statements of all 54 hospital departments were reviewed to determine which departments could be classified as revenue producing and which as nonrevenue producing. Of the 54 departments reviewed, 18 did not produce revenue as determined by the fact that no revenue appeared on either their departmental financial statements or departmental budgets. These departments are identified in Table 3. From the financial statements of these 18 departments, I determined that the expenses of the departments that did not produce revenue were the source of 34.0% of the total operating expense of the hospital (Fig. 4). The expenses included salaries, departmental supplies, purchased services, repair and maintenance, equipment rental, education, and other miscellaneous expenses associated with departmental operation. Operational expenses already accounted for in the P & L (eg, utilities, JCAHO expense, general and malpractice insurance) were deducted from the individual departmental financial statements and not counted twice. When the expense of departments not producing revenue was factored in as a percentage of each revenue dollar generated during that fiscal year, it revealed that 17.8% of each revenue dollar generated went to meet the expenses of departments that do not produce revenue.

Table 3. Hospital Departments That Do Not Produce Revenue

Administration	Accounting
Nursing Administration	Data Processing
Human Resources	Dietary Services
Social Services	Housekeeping
Administrative Services	Laundry
Quality Assurance	Medical Records
Education	Plant Operation
Public Relations	Biomedical Engineering
Business Office	Outpatient Services

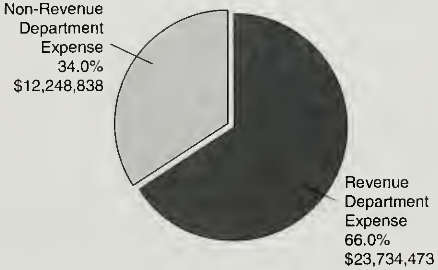

Fig. 4. Contribution of revenue-producing departments ■ vs contribution of departments that do not produce revenue □ to total operating expenses.

When this $0.178 in expense for nonrevenue-producing departments is added to the $0.233 in hospital expense, the $0.357 in contractual deduction and the $0.137 in respiratory care departmental expense, the Respiratory Care revenue dollar is now worth $0.095 as illustrated in Figure 3D.

Revenue-Producing Department Break-Even Point

If the Respiratory Care Department had a contribution margin of 86.3% of each revenue dollar generated and only contributed 9.53% of each revenue dollar, or $0.095, to the hospital bottom line, then the break-even contribution margin for revenue-producing departments is 76.77% (86.3% − 9.53% = 76.77%). Those departments with a contribution margin greater than 76.77% are contributing revenue to the hospital bottom line. Those departments with a contribution margin less than 76.77% are effectively cost centers.

The top 10 revenue-producing departments and their associated contribution margins are listed in Table 4. You will note that of the 10 highest revenue-producing departments in the hospital, only 4 have a contribution margin greater than 76.77%.

Table 4. The Top 10 Revenue-Producing Departments in the Study Hospital

Department	Revenue	Contribution Margin*
Pharmacy	$9,620,548	77.9%
Laboratory	$7,839,139	77.5%
Respiratory Care	$6,145,158	86.3%
Nursing Service	$5,610,885	58.8%
Central Supply	$4,416,433	52.9%
Outpatient Surgery Center	$4,290,000	68.2%
Radiology	$3,645,266	72.9%
Rehabilitation	$3,131,700	43.2%
Operating Room	$2,624,000	67.8%
Computed Tomography	$1,673,576	85.2%

*Contribution margin = gross revenue − operations expenses.

Table 5 lists the top 10 departmental contribution margins and their associated revenues. These are the departments that are effectively generating the revenue in excess of expense. Because 76.77% is the break-even contribution margin for revenue-producing departments, the percentage contribution margin above the 76.77% break-even would be the percentage of revenue contributed to the hospital bottom line. Table 6 lists the top 10 contributors of revenue to hospital profitability in descending order.

Table 5. The Top 10 Departmental Contribution Margins

Department	Contribution Margin	Revenue
EKG	94.2%	$1,211,324
Noninvasive Cardiovascular Laboratory	90.0%	$ 818,990
Cardiac Stress Testing	89.1%	$ 311,133
Laser Surgery	89.0%	$ 122,400
Respiratory Care	86.3%	$6,145,158
Computed Tomography	85.2%	$1,673,576
Ultrasound	84.9%	$ 604,421
Endoscopy	81.4%	$ 916,900
Nuclear Medicine	77.9%	$ 604,421
Anesthesia	77.7%	$ 378,625

Discussion

As Table 6 illustrates, the Respiratory Care Department was the largest contributor—$585,634.00 (which was 42.8% of the total revenue above expenses)—to the hospital's profitability in fiscal 1993. I know of no sound fiscal reasons for taking one of the most efficient departments and the largest contributor to hospital profitability and disbursing its resources to other departments. This study has shown that respiratory care departments may not always be the cost centers that some would have us believe. However, this does not relieve us of our responsibility to be cost-efficient. As the health-care reimbursement 'belt' tightens and hospital profitability shrinks from the present 2-3% to 1-2% or less, we must be aggressively proactive in cost control and in strengthening our fiscal position within the hospital. We must be aggressively pursuing therapist-

Table 6. The Top 10 Contributors to Hospital Revenues above Expenditures, or Bottom Line*

Department	Contribution Margin	Gross Revenue	Contribution Above Break-Even	Contributing Revenue
Respiratory Care	86.3%	$6,145,158	9.53%	$585,634
EKG	94.2%	$1,211,324	17.43%	$211,134
Computed Tomography	85.2%	$1,673,576	8.43%	$141,082
Pharmacy	77.9%	$9,620,548	1.13%	$108,712
Noninvasive Cardiovascular Laboratory	90.0%	$ 818,990	13.23%	$108,352
Laboratory	77.5%	$7,839,139	0.73%	$ 57,226
Ultrasound	84.9%	$ 604,421	8.13%	$ 49,139
Endoscopy	81.4%	$ 916,900	4.63%	$ 42,452
Cardiac Stress Lab	89.1%	$ 311,133	12.33%	$ 38,363
Laser Surgery	89.0%	$ 122,400	12.23%	$ 14,970

*Hospital bottom line is $1.368 million.

driven protocols and critical pathways to become even more efficient and cost-effective in providing our services.

We must become multiskilled practitioners now. An article in "Hospital and Health Services Administration"[4] cited the most frequently grouped multiskilled practitioners, by a survey of health-care executives, to be respiratory care practitioners and electrocardiograph technicians. If our Respiratory Care Department were to assume the responsibilities of the Noninvasive Cardiology Product Line (ie, EKG, Cardiac Stress Lab, and Noninvasive Cardiovascular Lab), then its services would represent 68.9% of the hospital bottom line!

This is the focus upon which health-care executives will be restructuring health care in the Year 2000. In today's health-care environment, it is sound fiscal reasoning to reduce cost and to strengthen those departments shown to be responsible for the financial viability of the institution.

Conclusions

This study has shown that our Respiratory Care Department has assumed a leadership role in the economic viability of our hospital and is the most cost-efficient contributor to health care. I do not believe that our hospital and our department are unique. I believe that many other respiratory care departments contribute to their hospitals' economic viability. It is our responsibility to build upon this role and assume our rightful position in health care of the Year 2000.

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AARC

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Therapist-Driven Protocols: The State of the Art

". . . my allegiance to respiratory care comes from my passion to improve patient care."

James K Stoller MD
Conference Chairman

On Friday and Saturday, May 13 and 14, 1994, the American Association for Respiratory Care (AARC) presented a special conference on therapist-driven protocols (TDPs) for managers, supervisors, and medical directors of respiratory care. The program, chaired by Dr James K Stoller of the Cleveland Clinic Foundation, Cleveland, Ohio, was attended by more than 250 people from all over the United States and Canada.

"Therapist-Driven Protocols: The State of the Art" was presented in 3 parts that covered introductory material, issues in implementation, and current experience with TDPs. The summary that follows is structured exactly like the program and written from the speaker's perspective so that you may more fully share, with all of us who attended, the impact of this conference.

Part I—Introduction to Therapist-Driven Protocols

Rationale for Therapist-Driven Protocols: Misallocation of Respiratory Care—James K Stoller MD

The development and implementation of TDPs have been on the rise since about 1980. The AARC's Poll conducted in 1993[1] showed that 60% of the institutions that responded had implemented TDPs or had immediate plans to do so. The reason for this growing acceptance is the misallocation—overordering or underordering—of respiratory therapy procedures that has been experienced under the traditional physician-order system of allocating respiratory care. Misallocation may be further defined as providing treatment to patients who don't need it and who stand not to benefit or not providing therapy for those who do need it and who do stand to benefit. Misallocation is due at least in part to misinformation about respiratory care. After all, medical students and house staff are not taught much about allocating respiratory care.

The evidence is clear that misallocation exists and may be reduced by implementing therapist-driven protocols (Table 1).[2-9] The issue is whether respiratory care practitioners (RCPs) can make the decisions and allocate appropriately. My impression is that in terms of ordering arterial blood gases, bronchial hygiene, or oxygen, RCPs are better prepared to allocate than are most others and their performance as allocators is better than anyone else's. Respiratory care practitioners are less likely to generate inappropriate orders than are non-RCPs. In a study at the Cleveland Clinic[10] comparing the clinical effects of our Respiratory Therapy Consult Service (RTCS) to the traditional physician-order allocation system, we found that misallocation was much less frequent under the RTCS (17% vs 43%). However, this issue needs to be rigorously tested in a randomized, controlled clinical trial.

Table 1. Frequency of Inappropriate Orders for Respiratory Tests or Services

Author(s), Year of Publication	Test or Service	Procedures Ordered Inappropriately
Brougher et al, 1986[2]	Oxygen administration	38%
Shapiro et al, 1988[3]	Bronchial hygiene	61%
Browning et al, 1989[4]	Arterial blood gases	36%
Hart et al, 1989[5]	Medicated aerosols	48.3%
Small et al, 1992[6]	Oxygen administration	23%
Lowe, 1992[7]	Pediatrics	26%
Kesler & Stoller, 1992[8]	5 non-ICU, adult services	25% over- and 10.5% underordered
Santoro et al, 1993[9]	Arterial blood gases	48.3%

The impact of therapist-driven protocols is not some futuristic concept; it is here and now. The truth of the matter is that misallocation is common and that overordering may occur more frequently than underordering. Allocation of respiratory care services by RCPs using therapist-driven protocols can potentially decrease misallocation without increasing adverse respiratory events and can help to control costs.

Positioning for Change—Sam Giordano MBA RRT

Why are changes in our health-care system inevitable?—because costs are soaring and the system is in-efficient. Therefore, our goal must be to make the current organization work more efficiently and to reduce costs where possible.

Selling the RCP. Think about selling RCPs to the health-care community. How can you show that RCPs contribute to positive clinical and economic outcomes?

- Conduct a situation analysis and identify your strengths and weaknesses. Begin by identifying the negatives (eg, irresponsible therapists) before someone else does it for you.
- Develop formal action plans to correct weaknesses and exploit strengths.
- Market your assets (skills inventory). RCPs have the largest skills inventory of any allied health professional—we are trained to administer prescription drugs; we have an incredible technical expertise, and we are in the hospital 7 days/week, 24 hours/day.

This will pave the way for implementation of TDPs. Remember, there is nothing wrong with RCPs who were on-the-job trained, but do not load your staff with people who have no formal training. Professionalize your department. We, as RCPs, are known as babysitters for equipment, which is correct. However, the perception that only the equipment interfaces with the patient is incorrect. We need to sell ourselves! We need to build our image as care coordinators, 'high-tech' experts, and broad-range caregivers.

Gather Baseline Data. You will need to gather baseline data regarding employee costs and turnover. Do a complete inventory: What is the average level of education of your staff members? We move in an environment in which academic degrees and credentials are important.

You must show that RCPs are more than can be seen on the surface. They are assessors, care coordinators, utilization controllers, resource managers, and consultants. The more people know about how comprehensively you have thought out your care plans, the more they will respect you as a professional. Stress the utilization reductions that can occur with TDPs; this will show that you are not task oriented. Remember, it is not essential that your department be the first to implement TDPs, but it is essential that you succeed when you do. RCPs must be perceived as professionals by physicians, nurses, and administrators. Mend fences as needed and strive to be well-liked. Or others may have cause to undermine your efforts to move forward. Strong medical-staff support that comes from longstanding excellence is essential. You simply must have the support and trust of the physicians in your institution. You can be empowered to succeed with protocols only if you have a record of excellence.*

RCPs Do More than You See. Use the AARC's Clinical Practice Guidelines[11-15] to position the RCP as a utilization coordinator. Lead with pilot projects—mistakes will not have such a huge impact, and you will have the opportunity to refine the protocols. Document the impact that your protocols have on length of stay, costs, and the institution's strategic objectives. Stress the benefit part of cost-benefit, and use your support from the medical staff to move ahead.

Decision makers are receptive to change right now. Take advantage of the opportunities while people are open-minded. What is driving the health-care bus? Money —make no mistake. You need to show that TDPs can save money without compromising quality.

Given the climate of health care today, with hospital restructuring leading a change in delivery and with government reform nipping at our heels, the fact is that the respiratory care profession will be redesigned. RCPs make a difference, but you must make that point clear if respiratory care departments are to succeed in this new environment.

Definition and Types of Therapist-Driven Protocols—Judith A Tietsort RN RRT

We have had TDPs in operation now for more than 20 years. It has not all been smooth or easy, but we have learned some things that might prove helpful to some of you.

We Must Move Forward. Whereas the traditional model (the physician orders and the therapist delivers) may have worked 20 years ago, it is not going to work in today's health-care environment. The Joint Commission on Accreditation of Healthcare Organizations[16] has added a generic standard for assessments that all health-care providers will be required to meet. Simply put, the Joint Commission requires assessments and you will be required to show that your RCPs know how to assess patients. A recent Health Care Advisory Board Review report[17] provides an excellent argument for those wishing to proceed with protocol development. That report says that the biggest cost-savings in hospitals today comes not from focused-care projects but from eliminating unnecessary care.

What Are Protocols? Protocols are not standing orders. They are patient-care plans initiated and implemented by a

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**Editor's Note: See related articles "Benefits Associated with a Respiratory Care Assessment-Treatment Program: Results of a Pilot Study" and "One Respiratory Care Department's Contribution to the 'Bottom Line'" on Pages 715 and 724 of this issue.*

credentialed RCP. They each have a title, purpose (therapeutic objectives), description of patients affected (eg, pediatric, postoperative), indications and contraindications, outcome objectives, and guidelines regarding when it is appropriate to reduce or discontinue therapy. Most of the information needed can be found in the AARC's Clinical Practice Guidelines.[11-15] Protocols must have been approved by the medical staff and hospital administration in the facility where they are used prior to implementation.

Protocols can take several forms—algorithms, narratives, or worksheets. They may be generic—these are generally patient assessment protocols where a doctor orders a general assessment of the patient's respiratory care needs. They can be based on diagnosis—part of the patient's critical path of care. Protocols may be based on symptoms—to treat atelectasis or wheezing.

The Nuts and Bolts of Implementing a TDP. In our hospital, the physician writes the order "Protocol." The RCP assessor chooses the critical pathway according to the diagnosis and notes the patient's symptoms and criteria for therapy. RCPs order, adjust, change mode, and request medical director consultation based on the algorithm. Everything can be managed with this method—from ventilation to pulse oximetry. However, assessment skills are very important and the skill level in your department must be adequate before you begin.

You will be required to spend more time with the patient, more time communicating with other professionals, and more time documenting what you have done and what you have observed. Therefore it is important not to reduce staff prematurely and based solely on your percent reduction in inappropriate therapy.

Many people believe that treating patients by protocol is cookbook medicine. Perhaps it is, but we still need a thinking cook.

Part II—Current Issues in Implementing Therapist-Driven Protocols

Judging the Efficacy of Therapist-Driven Protocols—James K Stoller MD

When we speak about outcomes with respect to TDPs, we refer not only to patient outcomes but to institutional, departmental, and caregiver (physician, nurse, and RCP) outcomes.

Patient Outcomes. Patient outcomes may be the number of treatments, types of treatments, adverse respiratory events such as requiring admission to the ICU for a respiratory cause, length of hospital stay, and length of requirement for and receipt of respiratory care services.

Institutional Outcomes. Institutional outcomes may be appropriateness of allocation of respiratory care, charges, and costs—respiratory costs, costs by DRG group, costs by diagnosis, and acuteness stratum. Health-care reform is not only about money—it is about resource allocation.

Physician Outcomes. Physician outcomes are concerned with the medical residents' absorption and retention of information about respiratory care of patients. They are further concerned with the impact of TDPs on private physicians' consults to pulmonary medicine.

Nursing Outcomes. The most important question here is, How easily do TDPs incorporate into the patient-focused model and critical pathways?

RCP Outcomes. RCP outcomes include job satisfaction, employee retention/turnover, and academic productivity.

We desperately need efficacy studies that test whether TDPs decrease misallocation of respiratory care services (over- or underordering). We also need to document whether a change in the kind or number of adverse respiratory events is seen after TDPs are implemented. We must determine whether TDPs work—are they effective and does their implementation go smoothly?

Desirable but not essential outcomes are whether the expense from respiratory care services goes down. If underordering is greater than overordering, expense will increase when appropriate allocation of respiratory care service is guaranteed. Another outcome we would like to measure is whether the volume of respiratory care service changes following implementation of TDPs. We would like to know whether the number of therapists required to accomplish the volume of service changes.

It will be important, at some point, to know whether patients spend less time in the hospital. Clearly, if length of hospital stay is due to a nonrespiratory condition, our TDPs cannot be expected to have an effect. It is also important to know that community physicians are still willing to consult with pulmonary medicine—we would like evidence that their confidence in us is unshaken. We would like to document that there is no change in consult patterns following implementation of TDPs for respiratory care service.

What Outcomes Should We Study? We must show that TDPs reduce the misallocation of respiratory care services without an increase in the incidence of adverse respiratory events—that in a controlled setting, TDPs are capable of making a difference. This is efficacy research.

We must show that TDPs decrease length of hospital stay and, if overordering is more prevalent than underordering, we must show that they reduce the cost of care—that in the real world of medical practice where the environment is not controlled, TDPs are not only capable of making a difference, they do make a difference. This is effectiveness research. Failure to document effectiveness, however, does not invalidate the efficacy of TDPs.

Putting a Therapist-Driven Protocol Together—Lucy Kester MBA RRT

Therapist-driven protocols are RCP-directed pathways for decision making. The purpose of guidelines and algorithms is to standardize decision making. The first step for the TDP committee is to establish indications for a therapy using the AARC's Clinical Practice Guidelines,[11-15] an exhaustive literature search, and institutional preferences. Using algorithms, patient assessment, and a chart review, the RCP can derive the indications for therapy.

At the Cleveland Clinic, the "standard drug regimen" is the method by which therapists can order drugs. Countersignature is required for some drugs for which indications are less clear and use is infrequent.

We use a triage score to determine treatment frequency. Patients whose severity of illness warrants a triage score of 1 receive therapy around the clock. Those whose triage score is 2 are treated QID and PRN at night. A score of 3 warrants therapy TID; with a score of 4, patients receive treatments Qshift while awake. These are usually treatments like breathing exercises and cough.

Basic Implementation of TDPs. The sequence of events that puts a protocol in operation are the physician's order for "respiratory therapy consult," the unit-clerk's call for the initial evaluation, the completion of assessment and care plan by the RCP, the administration of therapy, the documentation of therapy and patient response, and re-evaluation every 3 days with therapy modification as often as Qshift, if needed. A credentialed RCP does all evaluations and re-evaluations. A Care Plan and Consult form are placed in the progress-note section of the patient's medical record. All future documentation is found there.

The initial problems encountered with TDPs were

1. the respiratory staff had a low self-confidence level that resulted in their being overzealous in writing care plans and reluctant to discontinue unneeded therapy; and
2. evaluations are time-consuming, and we were not given additional staff to cover the increased patient-care time required.

Modifications have been made since the initial publication in RESPIRATORY CARE.[10] We have refined our algorithms, evaluation forms, and the re-evaluation process, and have developed a handbook for residents and others.

Starting a Therapist-Driven-Protocol Program—Judith A Tietsort RN RRT

TDPs are a logical answer to problems exposed by your quality assurance and improvement activities that include problem identification, data collection and analysis, action-plan development and implementation, monitoring of the results, and presenting the data to the medical staff.

Following are some suggestions that may help you to succeed in TDP implementation.

1. Caution: Do your own audit; do not use someone else's data.
2. Study the outcome in terms of costs, not charges. If you have a certain cost per unit service and if you decrease the number of units of service you provide, costs will go down.
3. Show that you can provide the procedure more cost-effectively than anyone else. (We're cheap, but good.)
4. Get your 'ducks in a row' with administration and your medical director. Encourage your medical director to become a member of the National Association of Medical Directors of Respiratory Care (NAMDRC).
5. Get the doctors and nurses to understand what you are doing and why.
6. Be sure the RCPs understand and are capable of 'pulling this off.'
7. Develop a task force consisting of the technical and medical directors of respiratory care, representatives of the medical records department, quality assurance and utilization review staff, the nursing department, and staff RCPs.
8. Clearly define the indications for starting and discontinuing the protocol.
9. Use RCPs to explain how the system works and physicians (medical director) to educate. This will enhance the acceptance of the protocol.
10. The key is to start small and to do it right the first time; you will not have a second chance.

Emphasize the advantages for physicians such as evaluation by an RCP who has passed a competency evaluation, lower cost of care, and ongoing flexibility. In our institution, we have a relative value unit attached to the cost.

Sell the program to the nurses on the basis of cost, quality of patient care, and RCP availability. Involve nurses in the care you normally provide. They can perform some basic duties. Care should be patient-focused not personal-needs (of the RCP) focused. The Medical Staff can help set the boundaries—the limits of the decisions that can be made by RCPs.

You must do quality assurance studies and recognize the obstacles to TDPs, such as physician and RCP resistance and the need for staff training and competency assessments.

Be prepared to do more than respiratory care. Expand your skills and knowledgebase to include Advanced cardiac life support (ACLS), electrocardiography (ECG), I.V. therapy, emergency medical technician training, hemodynamic monitoring and arterial lines, and even correspondence nursing school. This will expand your view of patient care.

Be prepared to teach and precept nurses, physical therapists, and other RCPs. Remember that when an RCP reports for work, he should interact with each patient as though having his job tomorrow depended on it.

Training Staff in Therapist-Driven Protocols—Lucy Kester MBA RRT

Education and orientation of the medical, nursing, allied health, and, in particular, the Respiratory Therapy Consult Service staff are probably the most important components of the success of our Consult Service. I present some of the unique features of our approach.

The medical director for respiratory care presents the structure and purpose of the program and teaches physicians, nurses, and RCPs; then, we let physicians teach physicians and RCPs teach residents. This approach helps ensure the uniform application of the algorithms.

Prior to the implementation of the protocols, staff were extensively trained in patient assessment and in the various components of application of the protocols. To maintain these skills and to assure uniform application, we use case-study exercises. We present three sets of four cases/set each year. Each case includes a scenario, triage score sheet, and a blank care plan. This approach shows whether staff are assigning triage scores consistently and following the algorithms based on the information they are given. It does not show whether RCPs gather the same information to calculate the triage score and develop the care plan. In the real world, if they pull different information, they may get similar or different triage scores.

In our hospital, new residents are given a copy of our handbook, which contains the algorithms and outlines the method for ordering a respiratory therapy consult, receive newsletters periodically, and are encouraged to collaborate with existing staff (MDs, RNs, and RCPs). The newsletters are also used to market the Consult Service and to repeat and reinforce information at physician and nursing staff meetings. Regular interaction with the nursing staff and unit secretaries is important to ensure proper use of the Consult Service. Good communication cannot be overemphasized.

Assessment Tools for Therapist-Driven Protocols—Dennis Giles RRT

The Conference on the Scientific Basis for In-hospital Respiratory Therapy[18] provided the impetus for the development of a patient assessment tool. The introduction of diagnosis-related groups, or DRGs, with the resultant reduction in reimbursement, resulted in reduced or, at least, flat staffing patterns that led to our inability to meet the demand for respiratory therapy services. We began to look for ways to prioritize patient care so that the most important needs could be met.

The early work in this regard was done at the New England Deaconess Hospital[19] where the need to establish patient-care priorities was recognized. They developed criteria for setting priorities that led to the triage rating system. Our experience at the Cleveland Clinic follows theirs. However we have attempted to validate our triage rating system by assessing interrater reliability and by continously monitoring its association with length of stay, days on respiratory care, charges for respiratory care, and total hospital charges.

The triage rating system evolved from the need to recognize indications for therapy, to develop assessment skills, and for a guided, systematic approach to patient assessment. The assessment consists of evaluating information in the chart, laboratory reports, and the patient. We use this information to generate the triage score, determine the frequency of therapy, and perform re-evaluations.

Quality Control for Therapist-Driven Protocols—David Haney RRT

At the Cleveland Clinic, we use a three-pronged approach for quality control in the Respiratory Therapy Consult Service—daily shift meetings, case studies, and internal audits. Using these monitoring devices, we can measure its effectivness.

Shift meetings are informal and consist of patient-condition updates, 'red-flag' evaluations, and an opportunity to reinforce the algorithms and reduce misallocation. The same objectives could be accomplished using a Journal Club format. *Case studies* are given to RCPs so that they can design a care plan; these are used to identify problem areas with regard to staff competency. *Independent audits* are conducted by RCPs who are blinded to whether patients are on the Consult Service or are being managed conventionally. Clinical indicators are selected for examination, and the review of these data prospectively enables us to ensure the absence of adverse respiratory events.

Impediments to Implementing Therapist-Driven Protocols—Doug Orens MBA RRT

The impediments to TDPs tend to come from different directions and may not be the same for all institutions. A strong commitment to TDPs is required because of increased patient severity of illness, increased demand for respiratory care service, and the reduction in full-time equivalents (FTEs) that often follows cost-cutting measures.

The Respiratory Care Department's medical director is a key person in the successful implementation of TDPs. He may hesitate to support your efforts to implement TDPs because the educational level of the RCPs is low, the political climate is not favorable, or he is not comfortable with the concept. The department manager is another key person. If he favors the status quo and is forced to cut costs by reducing staff, he may feel he lacks the resources to develop and implement TDPs. Efforts to move forward with TDPs may be hampered by respiratory care staff members who are not motivated or willing to assume extra responsibility. Finally, your hospital administrator must be on your team—not bent on reducing your staff to reduce costs.

In each individual institution, as you plan for TDPs,

- understand your environment;
- develop a strategic plan;
- prepare to be challenged; and
- allow for flexibility in your program.

To succeed, it is essential that you anticipate the impediments and have a plan to meet and overcome them.

Educational Aspects of TDPs: Are We Adequately Training Students?—Rebecca Meredith RRT

If TDPs are to succeed, we must have RCPs who are intrinsically capable of good patient assessment. People who think in concrete terms may not be capable of thinking analytically. They are usually extremely uncomfortable with critical decision making, which is essential for patient assessment and care-plan development. We need to foster critical thinking and analytical thinking in our students and stop limiting them by goal-oriented, objective-directed education.[20]*

Legal Aspects of Therapist-Driven Protocols: Do TDPs Place RCPs in a Legally Compromising Position?—Michael J Meehan Esq

The reality in the practice of law is that the defense attorney gets paid by the hour and the plaintiff's attorney gets paid a percent of the settlement—up to 50% in the state of Ohio. Lawyers must zealously act on behalf of their clients within the bounds of the law. Most view the courtroom as a place where justice must prevail, but that is not always the case.

The elements of malpractice are the defendant's duty to the plaintiff, the plaintiff's claim that the defendant breached that duty, that injury resulted from that breach, and that the defendant is liable for that injury.

The RCP's scope of practice includes evaluation, treatment, assessment, and care of the cardiopulmonary patient but, as the Ohio Respiratory Care Practitioner law states, RCPs practice "... upon the prescription of and under the supervision of a licensed physician."[21]

Duty of an RCP. "... to employ that degree of skill, care, and diligence that a respiratory therapist of ordinary skill, care, and diligence would employ in like circumstances."[21] RCPs are skilled professionals, but juries are not made up of skilled professionals. During a trial, expert witnesses are called to inform the jury on technical matters. Members of a jury don't have a clue about medical matters—a status that must be maintained because if a juror were an RCP, he would bias the whole jury, and they would not be able to render a verdict based on unbiased consensus. Therefore, he would be excused as a juror in a case in which an RCP were accused of malpractice.

Respiratory therapists are required to exercise judgment within the context of TDPs. They determine acuteness of the patient's condition, assign a triage score, and document their findings in the patient's medical record. The Joint Commission requires that hospitals have written policies that specify the scope and conduct of the practice of respiratory care, that these policies be approved by the medical staff and be enforced, that the medical director be a physician on staff who has special knowledge of respiratory care, and that nonphysician RCPs perform potentially hazardous patient procedures (eg, arterial punctures) only when authorized in writing by the medical director and in accordance with medical staff policy.[22]

Although there have been no cases brought against RCPs acting under therapist-driven protocols, clearly, TDPs increase the practitioners supervisors and medical director's liability. The risk, under this liability, is lessened somewhat when TDPs are common practice in a given state or are covered by institutional policy. TDPs are defensible as long as they are based on national standards (clinical practice guidelines that have been reviewed by experts that includes physicians) and are in accord with standards of care of physicians and nurses. There must be multilevel approval including the respiratory care-department administration, medical director, medical staff, and hospital itself.

Possible Pitfalls. Possible pitfalls of TDPs include purporting TDPs as a new standard of care within the institution, deviating from the protocol, inappropriate use of the

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Editor's Note: Ms Meredith expands this topic in an editorial elsewhere in this issue.

protocol, and negligent training of the staff. Allowing a staff member who has not demonstrated or has failed to demonstrate competency to work under TDPs is a dangerous practice. Not all respiratory therapists should be participating in TDPs.

The legally defensible TDP program is one that has written protocols approved at all levels of medical and hospital administration, is based on guidelines that have been reviewed by experts including physicians, has adequately trained staff whose competency is monitored, and has reviewed and updated the protocols periodically and as needed.

Part III—Current Experience with Therapist-Driven Protocols

The Lutheran Medical Center Experience—
Judy Tietsort RN RRT

Our hospital is a 400-bed, general acute-care, private, not-for-profit institution. The respiratory therapy department was started in 1972 and today has 30 acute-care therapists, 1 manager, and 4 additional administrative days/week shared by 3 therapists. All therapists work in all areas and undergo identical training programs. We work with a single group of 5 pulmonologists.

At its inception, our department rendered inconsistent and unnecessary therapy—that is, people with the same disease often got different treatment. In 1974, we began to work under protocols. These are patient-care plans initiated by RCPs, designed, developed, and approved by the medical staff. They allow up- and down-regulation of intensity of therapy and change in mode or discontinuation when appropriate. Our goals in 1972 were to give appropriate therapy at the appropriate time, educate the physicians as to the state of the art of respiratory care, concentrate on preoperative patient education, and identify preoperative patients at high risk for a poor outcome. At that time we provided primarily inhaled vapor, nebulized bronchodilator, postural drainage, and IPPB.

In 1994, 98% of all patients receive therapy via protocol and are evaluated for appropriateness and frequency with each treatment. All therapists are trained to do protocols and are oriented first to floor therapy, then to ICU, and finally to supervision. Our current goals are to deliver appropriate and timely therapy, to refer patients to the appropriate respiratory therapy service, to provide community and caregiver education (our department offers about 50 presentations/year), to identify high-risk preoperative patients, and to validate our service with outcome studies. Patient education takes place using care paths, preoperative teaching, respiratory care unit team education, nicotine/smoking-cessation education, and the emergency room therapist. In the community, RCPs offer instruction through the speaker's bureau, pulmonary rehabilitation department, Asthma Center, and sleep disorders laboratory.

The concept of the 1970s—give treatments, bill, receive reimbursement, contribute to the hospital's operating budget—the concept of profit center is passé; all departments are cost centers today, and the important concept is the ratio of costs to charges. For example, in our rehabilitation department, we lose money every day. However, all we must do is prevent a few patients from being admitted to the hospital in order to control costs.

Education has become our Number 1 focus for hospital caregivers, patients, outpatients, and members of the community.

The Fox Chase Cancer Center Experience—
Rich Malloy BS RRT

Our center is a 125-bed, full-service cancer center, and we report a 5-year experience with TDPs. There are 3 methods by which patients receive respiratory therapy: the traditional method wherein the physician writes the order and the RCP responds with the ordered therapy; the mixed method wherein the physician writes the order for therapy and the therapist has some latitude to modify the therapy based on his assessment; and the protocol/care plan method, which is based on scientifically derived indications for therapy and is fully RCP directed. The latter is born of the hospital administration's desire to decrease unnecessary respiratory care. In our institution, the physician institutes care by stating the patient's problem or diagnosis and any order for respiratory therapy service is interpreted as an order for a respiratory care plan. The care plan is developed using branching-logic scenarios (for example, if the physician stated his goal for respiratory care was to prevent atelectasis, we might perform incentive spirometry).

After implementing care plans, we found that we spent less time providing general care and more in educational activities such as ACLS certification.[23] Chest percussion therapy was reduced to near zero in 3 years. Orders for ABGs were far fewer because we insisted on criterion-based orders—in their absence we used noninvasive assessment of blood gases. We have seen no decrease in days of oxygen use. In fact, we have seen a slight increase. Incentive spirometry has decreased slightly. Metered-dose inhalers increased in 5 years from 165/year to 4,600/year. ABGs decreased from 6,700/year to 2,800/year. Bronchodilators administered went from 7,777/year to 3,700/year. Manpower requirement decreased from 17 FTEs to 12.5. In 1986, before the implementation of care plans, we projected that operating costs would steadily increase. Since the implementation of care plans, they have markedly decreased. Today, we spend 45% of our resources to provide critical care, 20% for general care, and 20% for ECGs.

Since the implementation of care plans, our department has been in compliance with the standards of the Joint Commission,[22] and we are spending less of our health-care resource to provide care. Our skills are more diverse, and we have more responsibility. Staff morale and retention has improved and most hospital staff seem to perceive RCPs in a more professional light.

The problems with care plans are communication difficulties among therapists, nurses, and physicians, the tendency of some therapists to be overly aggressive, the tendency of other RCPs to be passive and just do what they are told, and the ongoing challenge to engender good clinical judgment in our staff members.

The University of Utah-LDS Hospital Experience—Tom East PhD

First and foremost, TDP team members must have a captain to guide them, to lead them in standardization of the process, to implement and perfect the program. I prefer to adhere to the KIS (keep it simple) principle—start simple with reasonable goals, put the plan in place, and allow the clinical demands to dictate the level of complexity needed. Communication between the consensus group and staff members is essential.

The ingredients for successful consensus are a commitment to research, collegiality, dynamic and respected leadership, a keen awareness of flaws in medical decision making, and 'glue' to hold it all together until the benefit is obvious.

When humans make decisions, many things may affect that decision such as memory, drama of the situation, other data, fatigue, emotions, stress, time of day, expectations, and intuition. As Dr David Eddy said, "It is simply unrealistic to think that individuals can synthesize in their head scores of pieces of evidence, accurately estimate the outcomes of different options, and accurately judge the desirability of those outcomes for patients. ... All confirm what would be expected from common sense: The complexity of modern medicine exceeds the inherent limitations of the unaided human mind."[24] The computer has no such limitations and may therefore standardize care and reduce errors in clinical decision making. Such a system has been used in over 111 patients with ARDS. The results are encouraging because, when compared to historical controls, mortality was reduced in patients who were managed using the computerized decision assistance.[25] We have embarked on a multicenter controlled trial to evaluate the benefit of computer-assisted management of patients who have ARDS and require mechanical ventilation. Preliminary results are encouraging.

Problems with computer-assisted decision making are that, in crisis, the number of protocol violations is quite high. Clinical testing and refinement are essential if programs like this one are to succeed. We have seen that detailed management of ventilator patients is possible, but it is not easy or cheap. At LDS Hospital, we have spent 30 person-years so far in the research and development of this system.

The Cleveland Clinic Foundation Experience—James K Stoller MD

The structure of the TDP program at the Cleveland Clinic is multifaceted and includes RCP evaluators, RCPs who deliver care, respiratory care algorithms, a triage score, a review process, and a quality management program used to monitor adverse events and assure uniformity of practice.

We run TDPs on all non-ICU floors and have an ongoing review process that has two focuses—patient-status review and Consult-Service review. The patient-status review takes place on each shift between the therapist and supervisor. The medical director of the Consult Service is available to answer questions and assist in problem solving. Weekly patient case reviews are conducted with the department manager, education coordinator, supervisors, and ward leader in attendance. The Consult-Service review is conducted to assess adverse events and misallocations of respiratory care services. These data are then presented to the hospital medical staff and administration.

The key point is that misallocation is common and the Respiratory Therapy Consult Service is a promising strategy for decreasing it. However, a randomized, controlled clinical trial with groups stratified by disease severity is needed to expose the true benefit from a Respiratory Therapy Consult Service.

The University of Michigan Hospital Experience—Theresa J Keppler BBA RRT

Our bronchodilator therapy protocol evolved from the traditional physician-ordered system in a stepwise fashion to its present state over a 10-year period. Our technicians completed training for implementing metered-dose inhalers as the standard method for delivering bronchodilator therapy in 1992. The RCPs have been doing their own assessments since 1990; physician compliance with the protocol has increased since that time. At this time, all bronchodilator therapy is administered only during waking hours. However, those patients who require frequent therapy ($\leq$ 3 hours) may be treated as needed at night. This protocol allows the patients more sleeptime. The protocols provide the indications for therapy, and, if there are none, the therapist may discontinue treatment. We have found that 98-100% of bronchodilator treatments are indicated under this protocol.[26]

Self-administration of bronchodilator is an option that we offer our patients who have used bronchodilators at home. To be eligible for this approach to care, the treatments must be indicated, the patient must be motivated and not physically limited, and the patient must be able to demonstrate, document, and reiterate proper technique. Once a patient is approved for self-administration, the RCP confirms the indication for therapy, supervises the patient's self-care over the first 24 hours, and communicates with the health-care team that this patient is on the self-administration plan. The final step is for the patient to sign an informed consent, which is placed in the chart.

The RCP's responsibility is to see that documentation gets into the chart immediately so that there is no miscommunication, to educate the patient, and to evaluate the patient every 72 hours. The patient's responsibilities consist primarily of documenting the time of therapy and side effects. According to recent data, they comply about 75% of the time.

We have estimated that costs are about $50,000 less than before the protocol was in place, and charges for bronchodilator therapy have been reduced more than $600,000.

The Memorial Mission Hospital Experience—Mark A Fogelman RRT

Our institution has 44 FTEs plus a pool of 8-10 students who work on an as-needed basis. In addition to our routine responsibilities (ie, general floors and ICU), we participate in the nurse-therapist interhospital transport team.

We began our experience with TDPs in 1980 when we successfully implemented the protocol for preoperative assessments. In 1984, we expanded to postoperative ventilator weaning protocols. By 1984, we had converted all IPPB to incentive spirometry or hand-held nebulizer treatments and then later converted these two therapies to patient self-administration protocols. Subsequently, we replaced chest physiotherapy with incentive spirometry and cough and bronchial drainage and hand-held nebulizer treatments with metered-dose inhalers, which are now also patient self-administered. Our respiratory care consult program has evolved into its present form—Pulmonary Team Case Management.

We employ a patient assessment coordinator who coordinates department protocol activity. We have seen no increase in FTEs since the inception of protocols. We enjoy strong physician support, including those in Pulmonary Medicine, Pediatrics/Neonatology, and Cardiac Surgery. The cardiac surgeons were the first to request a protocol—they wanted a postoperative ventilator weaning protocol. In our hospital, the Family Practitioners are our 'bread and butter.' We continue to negotiate the case management concept, but they are somewhat more resistant than other physician groups.

The results of our post-protocol surveillance are shown below.

> **Study 1**: We looked at our time and charges for 55 cases during two 15-day periods before and after our patient assessment coordinator was hired. Time and charges decreased by 54% from the first to the second period.
>
> **Study 2**: We gathered data on 973 patients who were admitted to our hospital. Approximately 9% were on treatments at home prior to the admission. Only 5% of the protocol decisions agreed with the physicians written order, but for 86% the physician agreed with the protocol's recommendations. These data are still being collected.
>
> **Study 3**: We studied 36 patients to compare the potential time of hand-held nebulizer therapy to metered-dose inhaler technique by patient self-administration. The time required for administration of hand-held nebulizer treatments was 376 hours/month, whereas the patient-self-administered metered-dose inhaler technique required only 10 hours/month. We had no readmissions to ICU and a very low rate of missed treatments (2.8% at the beginning and currently 2.1%).

Our next step, as we expand our program, is to increase our patient assessors to two or more FTEs or make the assessments a regular staff assignment on our 12-hour shifts and to develop methods by which to measure the competency of RCPs and the medical staff in using protocols.

The University of California at San Diego Experience—Richard M Ford BS RRT

We are a Level-1 trauma center with life-flight service and 20% ICU beds. We are an adult-pediatric center and the regional center for patients with cystic fibrosis. We see 120-150 non-ICU adult patients/day on our service, run 25 ventilators/day, generate $23 million revenue, and spend $2.1-2.3 million/year to operate our department.

In order to implement changes intended to make care more cost effective, we formed a Respiratory Care Clinical Operations Team in January 1992 that was made up of respiratory care managers and staff who recognized the potential for reducing costs and improving care by implementing patient-driven protocols (PDP), or TDPs. This team had been functioning for less than 12 months when the consulting team, retained by the medical center to develop hospital-wide cost-cutting strategies, arrived.

We implemented PDPs on a single medical floor during January 1993, the same month that the consulting team arrived. The early results of this project provided powerful evidence of what could be accomplished with this approach. We experienced nearly a 60% reduction in aerosol and chest physiotherapy treatments within the first 90 days.[27] Routine treatments, including these just mentioned, added to about 7,000 treatments/month prior to implementation of PDPs and decreased to 4,000. This reduction resulted in a decrease in FTE requirement for that area from 5.6 to 2.5. With these data, we were able to cause a critical shift in thinking that the real issue in re-engineering delivery of respiratory care was not who should do what, but who is best suited to ensure that resources are consumed by only medically essential interventions.

PDPs have since been developed for the other primary respiratory care services and implemented in all areas of the hospital except pediatrics and the ICUs. Measurable reductions in the costs of providing respiratory care have occurred—they are estimated to exceed $150,000 by the end of this fiscal year. No adverse events have been attributed to our PDP program to date.

We now have 13 protocols. Among them are protocols for liver transplant patients, extubation, secretion clearance for ventilator patients, and weaning from mechanical ventilation. Within the next 9 months, we will have protocols for ventilator management, heart-lung-transplant patients, and inverse-ratio ventilation.

Our PDPs are structured to include sections on purpose, scope, policy, and equipment required. Our algorithms include transitions from one method to another. For example we have a Hayek oscillator, a Bird Percussionator, and a ThAIRapy system that we use for secretion clearance. The indications for transition from one method to another are clearly stated. We have policies for treatments with questionable benefit such as bland aerosol, hand-held nebulizer treatments for patients who can use MDIs, and Mucomyst—we don't do them!

When the physician writes the order for "RC protocol," the RCP does an assessment, defines the care plan, identifies opportunities for transition for additional care, and reevaluates the patient every 24 hours. The coordinator identifies patients on protocol who need evaluation, ensures that care plans are consistent, serves as a resource person, monitors the PDP program, and reports the results of that monitoring.

We incorporate a management information system for respiratory care that is a point-of-care, field-driven, computerized charting system. Certain fields are mandatory. For example, mandatory fields in the chart of a patient with wheezing are peak flows and an assessment of secretions before and after treatment. Unless entries are made to these fields, the RCP cannot exit the record.

We have been able to reduce the cost of providing respiratory care. Our physicians' ordering practices are changing, and we are experiencing a reduction in the demand for FTEs. Certain factors have emerged as key to our success: patient-focused environment, adhering to information from research, internal analysis and pilot implementation, quality management, ownership by nurses and physicians, medical director's support, controlled resource allocation, and TRAIN, TRAIN, TRAIN!

Common barriers to successful implementation of PDPs are job security concerns, surveillance requirements, information management required for PDPs, RCP training, and rotating house staff.

Regardless of the barriers, we are being asked to do less with less and that is disconcerting. However, we must search and be ready for opportunities to take on other responsibilities and do new things. Let us expand our horizons. Dare to imagine and shift our thinking about the delivery of respiratory care services.

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PFT Corner #52—Cardiopulmonary Exercise Testing in the Preoperative Evaluation of Patients with Lung Cancer

DeeAnn Miller RRT and Jeff Wilson MD

Case Summary

A 54-year-old woman with a 40 pack-year smoking history was referred to our pulmonary clinic in December 1991 for evaluation of a new lung mass in her right upper lobe. She reported a 1-month history of hemoptysis but no weight loss, fever, chills, weakness, or fatigue. She was on no medication. She had undergone a left pneumonectomy in 1978 for adenocarcinoma but had done well since that time, although she continued to smoke one pack of cigarettes per day.

On physical examination, her vital signs were stable, and there was no adenopathy. On auscultation, breath sounds were markedly decreased on the left and clear on the right. Heart sounds were normal, without gallop or murmur. The extremities were without cyanosis, clubbing, or edema.

Laboratory studies revealed a platelet count of 325,000 cells/mm^3 [325 × 10^9 cells/L]; WBC 7,200 cells/mm^3 [7.2 cells/L]; Hb 12.7 g/dL [127 g/L]; and Hct 40 vol% [0.40].

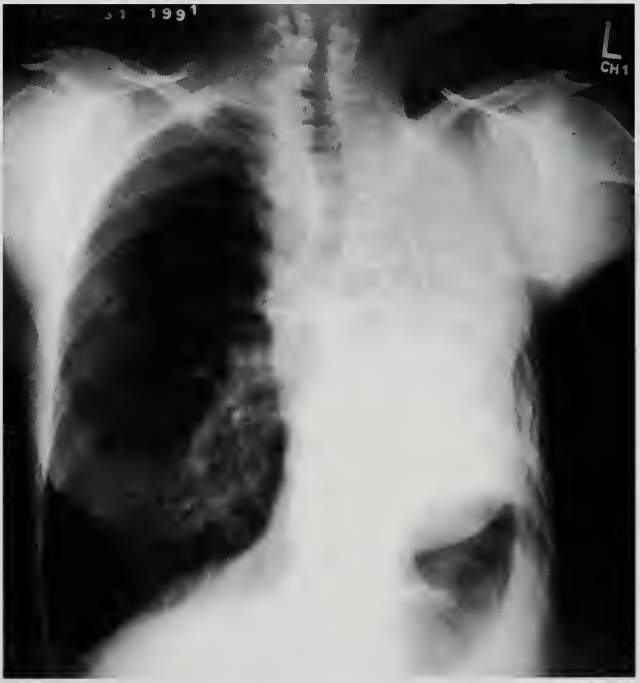

Fig. 1. Chest radiograph of 54-year-old woman revealing volume loss and opacification of the left hemithorax from her previous left pneumonectomy, and a new 2-cm right upper lobe cavitary nodule.

The chest radiograph revealed a new 2-cm noncalcified mass in the right upper lobe (Fig. 1). Computed tomography of the chest confirmed the mass and gave evidence of enlarged mediastinal lymph nodes (Fig. 2).

Transbronchial biopsies in the right upper lobe taken during bronchoscopy revealed non-small-cell carcinoma.

Results of pulmonary function tests and arterial blood gas analysis are shown in Tables 1 and 2.

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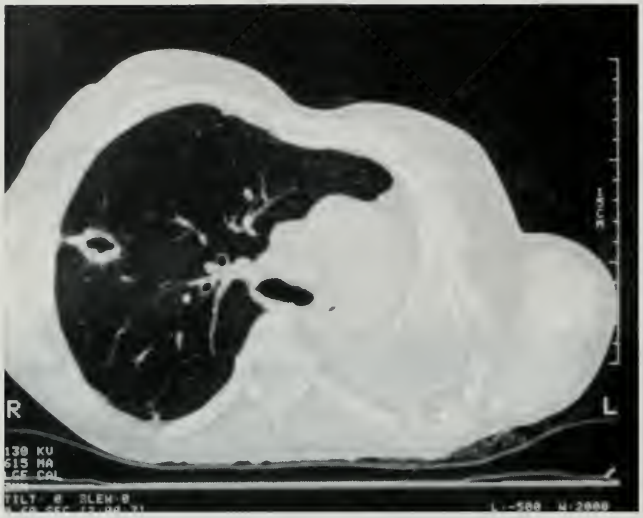

Fig. 2. Computed tomography confirmed a 2-cm right upper lobe nodule without evidence of other parenchymal masses.

Table 1. Results of Spirometry and Diffusing Capacity in 54-Year-Old Woman, with 40 Pack-Year Smoking History and Left Pneumonectomy

Test	Results	% Predicted*
FVC (L)	1.59	55
FEV_1 (L)	1.13	52
FEV_1/FVC	0.71	
$FEF_{25-75\%}$ (L/s)	0.73	28
FEF_{max} (L/s)	4.53	78
D_{LCO}-CORR (mL · min^{-1} · $torr^{-1}$)	18.21	82
D_{LCO}/V_A	4.86	105
V_A (L)	3.55	74

*Not accounting for pneumonectomy.

Table 2. Results of Arterial Blood Gases on Room Air

Value	Measured	Normal Range
pH	7.42	7.36-7.44
P_{aCO_2} (torr)	46	36-44
P_{aO_2} (torr)	83	85-100
HCO_3 (mEq/L)	29	20-25

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Table 3. Results of Preoperative Cardiopulmonary Exercise Test in a 54-Year-Old Woman with Left Pneumonectomy

Measurement	Measured	Predicted
Maximum $\dot{V}_{O_2}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	20.8 (86% predicted)	24.1
Maximum HR (beats/min)	155	166
Maximum $\dot{V}_E$ (L/min)*	52	61
Breathing reserve	15%; 9 L	≥ 20%

*Also known as MVV.

Answers

PFT Interpretation: Spirometry reveals a moderately severe ventilatory defect that is neither clearly obstructive nor restrictive and is consistent with her previous lung resection. The low-normal D_{LCO} can be seen even after resection of an entire lung due to the large amount of recruitable capillary bed in the remaining lung.

ABG Interpretation: A mixed respiratory acidosis and metabolic alkalosis with normal oxygenation.

Further Testing: Due to patient's low FEV_1 and FVC, hypercarbia, and previous left pneumonectomy, we were concerned that this patient would be at high risk for respiratory failure if further lung resection were undertaken.

Results of early studies led to the prediction of postoperative complications and poor risk for lung resection based on abnormal pulmonary function.[1-3]

In 1962, Stein et al[2] found that 21 of 30 patients (66%) with abnormal preoperative pulmonary function developed postoperative complications. Their criteria suggesting an increased risk were an FVC < 2 L (70% of predicted), FEV_1 < 1.2 L, a D_{LCO} < 50% predicted, and a P_{aCO_2} > 45 torr. Lockwood[3] reported the following pulmonary function parameters to indicate high risk for lung resection: FVC < 1.70 L, FEV_1 < 1.2 L, or < 35% of the FVC. These values, however, were not corrected for the patient's sex, race, weight, and age.

In recent years, many studies have related the results of exercise testing to prediction of surgical outcome and have provided new criteria for the definition of high surgical risk. Exercise studies are another method of predicting postoperative status. Because surgical resection was felt to be this patient's best chance for long-term survival, a cardiopulmonary exercise test was performed to further assess her cardiopulmonary reserve (Table 3).

Based on the results of her exercise test showing a peak $\dot{V}_{O_2}$ > 20 $mL \cdot min^{-1} \cdot kg^{-1}$, we believed that she could tolerate a resection as extensive as a right upper lobectomy. She underwent mediastinoscopy, which was negative, followed by a right-upper-lobe wedge excision of the lesion. She was extubated in the operating room and admitted to the surgical intensive care unit on 40% oxygen by face mask. After 1 day in the surgical intensive care unit, she was transferred to the ward. She developed no cardiopulmonary complications and was discharged home after 6 days in the hospital. Her final pathology report showed a large-cell carcinoma, with no positive lymph nodes. She was last seen in follow-up several months later and had continued to do well. Postoperative pulmonary function and exercise testing were not performed. She eventually died from local recurrence of her disease.

Discussion

This case illustrates the use of preoperative cardiopulmonary exercise testing for patients with lung cancer, who might not be offered surgery due to poor static lung function tests. It was felt that this patient was at high risk for further lung resertion surgery due to her previous pneumonectomy, low FEV_1 and FVC, and hypercarbia. The results of her cardiopulmonary exercise test suggested, however, that she could tolerate further resection.

Most,[4-7] but not all,[8,9] studies examining the use of cardiopulmonary exercise testing in the preoperative assessment of patients with bronchogenic carcinoma have reported an abnormally low maximal oxygen consumption ($\dot{V}_{O_2max}$) to be the best predictor of perioperative cardiopulmonary complications. In 1984, Smith[5] and colleagues reported that 10% (1/10) of patients with a $\dot{V}_{O_2max}$ > 20 $mL \cdot min^{-1} \cdot kg^{-1}$ experienced perioperative complication, whereas 67% (4/6) of patients with a $\dot{V}_{O_2max}$ of between 15 and 20 $mL \cdot min^{-1} \cdot kg^{-1}$ and 100% (6/6) with $\dot{V}_{O_2max}$ < 15 $mL \cdot min^{-1} \cdot kg^{-1}$ experienced significant complications. Importantly, only maximal oxygen consumption discriminated between those who would go on to experience complications and those who would not. FEV_1, FVC, and D_{LCO} were not significantly different between the two groups. Similar results have been reported by Eugene et al[4] and Bechard and Wetstein.[6] Recent data from Morice et al[7] suggest that patients with bronchogenic carcinoma who would be deemed medically inoperable by traditional criteria for pulmonary function, but who have a $\dot{V}_{O_2max}$ > 15 $mL \cdot min^{-1} \cdot kg^{-1}$ can undergo wedge resection or lobectomy with minimal complications. However, not all studies have found $\dot{V}_{O_2max}$ to be the best predictor of complications following lung resection. Possible explanations for this finding include (1) the inclusion of data from patients with submaximal tests (virtually none of the studies have included information to enable judgment of whether each test was a maximal effort); (2) inclusion of perioperative complications of a technical nature as well as cardiopulmonary complications (one would not expect that blood loss, for example, could be predicted by the results of a cardiopulmonary exercise test).

Conclusion

We feel that cardiopulmonary exercise testing is useful for assessing perioperative risk in patients with lung cancer who are being evaluated for lung resection. The test is most useful in identifying patients who might otherwise be denied thoracotomy based on resting pulmonary function data. Surgical resection is the only treatment modality associated with long-term survival in patients with non-small-cell lung cancer. Thus, it seems reasonable to offer lung resection to those patients in whom perioperative complications are unlikely. In general, we recommend surgery to patients with proven or suspected clinical Stage I or II bronchogenic carcinoma, if they can achieve a peak $\dot{V}_{O_2}$, or $\dot{V}_{O_2max}$, > 15 $mL \cdot min^{-1} \cdot kg^{-1}$. This approach is used even when resting pulmonary function test results are poor, provided resection can be accomplished with a lobectomy or less. We also would not automatically deny surgery to patients with a $\dot{V}_{O_2max} < 15\ mL \cdot min^{-1} \cdot kg^{-1}$ if their pulmonary function tests are acceptable. Such a situation can be seen in elderly or obese patients and does not contraindicate surgery. Whether a $\dot{V}_{O_2}$ can be safely reduced below 15 $mL \cdot min^{-1} \cdot kg^{-1}$ as an acceptable lower limit for lung resection is unknown and requires further investigation.

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Letters

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Chatburn's Ventilator Classification Scheme—A Poor Substitute for the Classic Approach

The specter of ventilator classification has, once again, materialized. According to letters to the editor and responses to them in RESPIRATORY CARE, the ability to properly classify ventilators still eludes some practitioners.[1,2] The recent wave of confusion originates with a so-called "new" system for understanding mechanical ventilators devised by Chatburn.[3,4] We agree with Chatburn that our ability to communicate about mechanical ventilators can be hampered by an inadequate classification scheme.[3] However, we take strong exception to his assertion that the problem results from "loose collections of unrelated facts" or because the conventional scheme, which was devised by Mushin, is "founded on descriptions of mechanical archetypes."[3] The problem is not the classification system itself but what the system seeks to organize: not simply a machine, but a machine that interacts with a physiologic system.

Because of the complexity of mechanical ventilators and mechanical ventilation, the task of understanding and classifying ventilators, a tedious and time-consuming endeavor, frustrates and confuses practitioners and is, at best, difficult. For instance, ventilator function can be based on any of a seemingly limitless array of different mechanical technologies. To make matters worse, depending on the classification system, some mechanical ventilators, like chameleons, change class in mid-breath. Indeed, it just might not be humanly possible to simplify such a complex system without sacrificing essential information and, thus, comprehension of it. Therefore, Chatburn's proposal for classifying ventilators[3-7] raises several questions in our minds. First, Is the system really new? More importantly, Does it really simplify or improve ventilator classification?

After reading and rereading explanations and discussions about Chatburn's proposed system,[3-7] it is apparent to us that it is not entirely new. In fact, Chatburn's system represents only a slight modification of the original system (Table 1); therefore, it is *exactly* what he claims it is not: "A variation on the classic work of Mushin et al first published in 1959."[4,8] Both systems culminate with a mathematical problem; Chatburn's approach, however, although deceivingly simple to apply, is more complicated (it has more steps) and lacks specificity (too many different ventilators end up with an identical classification), which results in confusion.

Without question, Chatburn was the first to propose the use of the Rhorer equation (equation of motion for the respiratory system) to classify ventilators. According to this proposal, in *theory*, a ventilator can control only one of the four variables in the equation of motion at a time (flow, pressure, volume, or time). By deciding which variable the ventilator "controls," we thus classify the ventilator as a pressure-, flow-, volume-, or time-controller. The remaining three "uncontrolled" variables become, by default, dependent (or response) variables. The concept of ventilator control coupled with the equation of motion superficially appears to offer an ideal basis for classifying ventilators. Unfortunately, in the real world, a ventilator designed—in theory—to control a particular variable when used for mechanical ventilation may in practice function quite differently. Furthermore, theoretical ventilator types do not necessarily translate into useful or practical ventilator designs. The Chatburn classification system, thus, becomes a two-variable classification because volume-controllers are impossible and time-controllers are impractical.

A volume-controller, by definition, is a technical impossibility. As Chatburn says, a volume-controller "must (1) main-

Table 1. The Mushin System of Ventilator Classification Contrasted with the Chatburn System*

Theoretical Phase	Mushin	Chatburn
Inspiratory	Inspiratory 1. Pressure generators —Constant —Nonconstant 2. Flow generators —Constant —Nonconstant	Inspiratory 1. Control variable —Pressure —Flow 2. Limit variable —Pressure —Flow —Volume
Cycling	Changeover phase (cycling; inspiration to expiration) 1. Time 2. Pressure 3. Flow 4. Volume	Cycle variable 1. Time 2. Pressure 3. Flow 4. Volume?
Expiratory	Expiratory phase 1. PEEP 2. CPAP	Baseline variable 1. PEEP 2. CPAP
Breath initiation	Changeover phase 1. Time 2. Pressure 3. Flow 4. Volume	Trigger variables 1. Time 2. Pressure 3. Flow 4. Volume

*Although Chatburn's scheme separates the control and limit variables, these variables operate only during the inspiratory phase and were so listed. Otherwise, except for order (Chatburn begins with breath initiation and Mushin with inspiration), the systems are virtually identical. PEEP = positive end-expiratory pressure; CPAP = continuous positive airway pressure.

tain an approximately constant volume waveform in the face of a varying load and (2) measure volume and use the signal to control the volume waveform."[4] In addition, to distinguish a volume- from a flow-controller, volume *must* be measured volumetrically (by displacement of a piston or bellows) and not by integrating flow with time.[3,4] Without using a body box (plethysmograph), it is virtually impossible to volumetrically measure a quantity of gas serving as a patient's tidal volume.

Time-controllers, although theoretically possible, offer no clinical advantage and might even be dangerous. With a true time-controller, flow, pressure, and volume vary in response to any variation in compliance or resistance. Thus, all mechanical ventilators must be either pressure- or flow-controllers. Does this sound familiar? Chatburn's system is virtually identical to Mushin's, which also classifies ventilators into two broad categories: pressure- and flow-generators. We are now left with the difference between a controller and a generator, and, in the context of mechanical ventilation, the words are synonymous. The Mushin system, however, is superior because it proceeds to further subdivide ventilators into constant and nonconstant variants, which yields a total of four basic ventilator types compared with Chatburn's two.

Chatburn's repeated claim that Mushin's scheme is based on "archetypes" that are "irrelevant,"[3,4] is clearly biased. Mushin's conception of constant and nonconstant pressure- or flow-generators was developed from a carefully reasoned theoretical framework, which resulted in a system that is, indeed, archetypical or prototypical—not in the sense of serving as a "model for a later period" but in the sense of serving as a "perfect example."[9] Put simply, Mushin demonstrated that physiologic variations in flow, pressure, or volume during mechanical ventilation result from mathematically definable interactions between the pressure generated (P_G) by the ventilator and the lungs. The relationship is just as valid today as it was more than 30 years ago. Contrary to Chatburn's assertions, the concept of P_G *does* apply to today's third-generation ventilators, which employ an astounding range of P_G: 0 to 120 cm H_2O (adjustable) with the Siemens 900C, 350 cm H_2O (approximately) with the Hamilton Veolar, 750 cm H_2O with the 7200, 1,875 cm H_2O with the Bird 6400ST, and a level equivalent to the particular peak inflation pressure (PIP) or support level with all ventilators capable of pressure-controlled ventilation (PCV) or pressure support ventilation.

Once one has learned Mushin's ventilator classification, it is more descriptive and provides more information than Chatburn's alternative. For instance, imagine a Siemens 900C with the following settings.

> Mode: volume control
> P_G: 70 cm H_2O
> Flow pattern: square waveform
> PIP: 60 cm H_2O

Using Chatburn's approach, these settings indicate that the ventilator is controlling flow. The classification of flow-controller, however, is misleading because, although the Siemens controls flow electronically, the regulated P_G is insufficient to overcome impedance; thus, inspiratory flow diminishes. That is, the flow pattern with these settings resembles a descending ramp rather than the programmed (flow-controlled) square wave. According to Mushin's more practical approach, when P_G fails to exceed the expected PIP by at least five times, inspiratory flow progressively diminishes throughout each mechanical breath. In this scenario, then, the Siemens is generating constant pressure, not controlling flow; therefore, it is best classified under these conditions as a "constant-pressure generator" not a "flow-controller." The resultant interaction between ventilator and lungs is precisely as described by Mushin.[8]

In another example, one author, using Chatburn's scheme, classifies an iron lung, the Bird Mark series ventilators, and the Bennett PR-2 as pressure-controllers[2] but then goes on to state that none of these devices is capable of PCV! In her response, Piedalue concurs that these ventilators are indeed pressure-controllers, but that it is "oxymoronic" to suggest that a pressure-controller cannot provide PCV.[2] Had these authors consulted Mushin, such confusion would have been avoided. Iron lungs, when classified as "nonconstant pressure generators" are, by definition, incapable of PCV—only a constant-pressure generator can produce PCV. The Bennett PR-2, on the other hand, functions as a "constant-pressure generator," and, thus, is capable of PCV, provided the ventilator is operated in the time-cycled mode.

Classifying the Bird Mark 7 requires knowledge of the equipment and the operating environment. With the air-mix control turned off, a Bird Mark 7 generates a constant flow (Mushin) or controls flow (Chatburn). Changes in impedance will not affect the flow pattern. With the air-mix control turned on, an air-entraining venturi provides a high initial flowrate (indistinguishable from PCV). In Mushin's terms, at the beginning of a breath, the Mark 7 generates constant pressure. Inspiratory flow, however, rapidly diminishes ("pneumatic clutching" according to Bird) and, once proximal airway pressure reaches approximately 12 cm H_2O, the venturi gate closes (entrainment ceases). For the remainder of the breath, the ventilator reverts to generating a constant flow.[10] That is, to prevent confusion, a Bird Mark 7, with the air-mix control on, must be classified differently depending on whether PIP is less than or greater than 12 cm H_2O Based on cycling criteria, the Mark 7 is incapable of PCV[2] (a Mark 7 cannot be time-cycled).

The aforementioned examples clearly illustrate the ambiguities fostered by the Chatburn approach; there are many others. These examples also demonstrate that simply classifying a ventilator does not necessarily translate into understanding that particular ventilator. A simple system is not bad per se, but when it becomes an *oversimplification*, problems ultimately result because it then discourages students from spending the time and energy required to learn and comprehend a superior but complex system.

In summary, to understand and coherently communicate about mechanical ventilators, the respiratory and critical care communities require an adequate classification scheme. Before adopting and implementing the Rhorer equation as the basis of ventilator classification, however, this modified approach should objectively demonstrate improvements in both arenas. The evidence presented here clearly illustrates that the Rhorer equation, although it seems to facilitate ventilator classification, does not facilitate our understanding of or our ability to communicate about ventilators. At best, Chatburn's suggested mathematic approach generates descriptions almost identical to, but not as informative as, those developed from Mushin's more pragmatic approach. This situation results because, even though a mathematical equation is the single most precise and reproducible method for representing scientific data, a single equation seldom adequately describes the tremendous number of biologic interactions in nature or, for that matter, in machines. As a result, Chatburn's approach introduces inflexibility into ventilator classification—a ventilator is defined by its control of only a single variable. In reality, however, ventilators often control different variables under different conditions. The predictable outcome of using such an inflexible classification scheme is double jeopardy: It instills false confidence while it obscures understanding.

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Chatburn responds:

Blanch and Desautels argue that (A) my classification system is ". . . virtually identical to Mushin's . . ." and (B) my system is worse because it is more complicated and less specific. Their first argument fails immediately on the basis of elementary deductive logic: If A is no different from B, then B cannot be better or worse than A. If my system is no different from Mushin's then how could it be worse? Because their logic is faulty, it is not surprising that their proof is inadequate.

They offer a table that compares Mushin's division of the ventilatory cycle compared to mine and conclude that they are only slightly different. In the first place, I have openly adopted and credited Mushin's idea of having four phases to the ventilatory cycle, and even credited Desautels with the concept of phase variables,[1] so one would expect the two systems to be similar on these points. But, more importantly, division of the ventilatory cycle accounts for only a fraction of the classification system. My system is based on control variables, phase variables, conditional variables, and conditional logic, all of which are founded on the equation of motion for the respiratory system (which Blanch and Desautels concede is an original basis for classification). I have defined the necessary and sufficient criteria for all these concepts and have extended the definitions to terms related to ventilator use (ie, modes of ventilation), such as the concept of mandatory and spontaneous breaths. I have even extended the system to include alarms systems. Such definitions have never before been presented in a systematic and coherent fashion, which is why there has been so much confusion. The only legitimate argument centers on the usefulness of the system, not its originality.

The real issue here is whether the new system is better (ie, more useful) than others. My criteria for judging quality are that the system (1) be based on a relevant theoretical framework; (2) be consistent with terminology from other disciplines and, where possible, with established concepts; (3) be specific and based on explicit definitions; and (4) provide adequate detail.[2] Blanch and Desautels say the new system is not useful because it is more complex and less specific. I say that the new system can have as much complexity as one wishes. With the outline approach I suggested,[1] one can specify as little or as much detail as desired. Let's take a sophisticated ventilator like the Puritan-Bennett 7200. The simplest description focuses on the control scheme: it is a pressure- and flow-controller. Or, one could specify: (1) the input power source (pneumatic), (2) the drive mechanism (proportional valve), (3) the control scheme (pressure and flow control with several phase variables and conditional logic options), and (4) the output in terms of pressure, volume, and flow waveforms (of which there are several). Each of these categories can have more detail if desired. From this proceeds specificity, again to any level of distinction required. That is the beauty and flexibility of the new system not seen in previous systems. I offer Table 1 as proof. If specifics of a "better" system are provided, we can have a meaningful discussion.

Blanch and Desautels claim that my system lacks specificity because too many ventilators end up with an identical classification. They try to invalidate the system by saying it can distinguish only pressure- and flow-controllers because "a volume-controller, by definition, is a technical impossibility." Are they ignoring the new Sechrist 2200B ventilator, the variety of piston-driven home-care ventilators, or even the older Emerson models and the venerable Bennett MA-1? All of

Table 1. The New Ventilator Classification System Applied to Some Current ICU Ventilators

	Bear 1	Bear 2	Bear 5	Bear 1000	Bear Cub	Bird 8400ST	Bird V.I.P.	Dräger Babylog	Emerson 3MV	Hamilton Veolar	Infra. Infant Star	Infra. Adult Star	Newport Breeze	Newport E100I	Newport Wave	PB MA-1	PB 7200	PPG IRISA	Sechrist IV-100B	Sechrist 2200B	Siemens 900C	Siemens 300
I. Drive Power*																						
A. Pneumatic	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●		●	●
B. Electric									●											●		
II. Drive Mechanism																						
A. Compressor																						
1. External			●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●
2. Internal	●	●							●							●				●		
B. Motor and linkage																						
1. Compressed gas/direct	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●		●	●
2. Electric motor/rotating crank									●													
3. Electric motor/threaded rod																				●		
C. Output control valves																						
1. Pneumatic diaphragm	●	●	●	●	●				●			●	●	●	●	●	●	●	●	●		
2. Pneumatic poppet valve								●				●	●	●								
3. Electric poppet valve	●	●		●	●			●			●		●	●	●		●	●	●	●		
4. Electric proportional valve			●	●		●	●			●		●			●		●	●		●	●	●
III. Control Scheme																						
A. Control circuit																						
1. Mechanical									●							●						
2. Pneumatic	●	●	●	●	●			●			●	●	●	●	●	●	●	●	●	●		
3. Fluidic																			●			
4. Electronic	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●		●	●	●
B. Control Variables																						
1. Pressure	●	●	●	●	●	●	●	●		●	●	●	●	●	●		●	●	●	●	●	●
2. Volume	●	●							●							●				●		
3. Flow			●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		●	●
C. Phase Variables																						
1. Trigger																						
a. pressure	●	●	●	●		●	●			●		●	●	●	●	●	●	●		●	●	●
b. volume								●														
c. flow	●	●				●	1										●					●
d. time	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
e. manual	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
f. optional external source											●											
2. Limit Variable																						
a. pressure	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
b. volume	●	●	●	●		●				●		●				●	●	●		●	●	●
c. flow	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●
3. Cycle Variable																						
a. pressure	●	●	●	●		●	●	●		●	●	●	●	●	●	●	●	●		●	●	●
b. volume				●			●		●							●				●		
c. flow			●	●		●	●			●		●			●		●	●		●	●	●
e. time	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
IV. Output																						
A. Pressure																						
1. Rectangular			●	●		●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
2. Exponential				●	●													●	●			●
3. Adjustable				●	2			2			2		2	2	2			●	2			●
B. Volume																						
1. Ascending Ramp				●												●						
2. Sinusoidal									●													
C. Flow																						
1. Rectangular	●	●	●	●	●	●	●	●		●	●	●	●	●	●			●	●	●	●	●
2. Ascending Ramp			●							●		●								●		
3. Descending Ramp	●	●	●	●		●				●		●					●			●		
4. Sinusoidal			●	●						●		●					●			●	●	
5. Adjustable	●																					
V. Alarms																						
A. Input Power Alarms																						
1. Loss of electric power	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2. Loss of pneumatic power	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
B. Control Circuit Alarms																						
1. General Systems Failure	●	●	●	●	●	●	●	●	●	●	●	●			●		●	●		●		●
2. Incompatible Settings				●	●			●		●	●	●			●							
3. Inverse I:E Ratio	●	●	●	●	●	●		●				●		●	●	●	●					
C. Output Alarms																						
1. Pressure																						
a. high peak	●	●	●	●		●	●	●	1	●	●	●	●	●	●	●		●		●	●	●
b. low peak	●	●	●	●	●	●	●	●	1		●	●	●	●	●		●	●	●	●		
c. high baseline			●	●				●			●	●										
d. low baseline	●	●	●	●	●	●	●			●	●	●					●					
e. high/low mean			●																			
2. Volume																						
a. low tidal volume	●	●	●									●					●			●		
3. Flow																						
a. High minute ventilation			●	●				●		●					●			●		●	●	●
b. Low minute ventilation			●	●		●	1	●		●		●			●		●	●		●	●	●
4. Time																						
a. High/low ventilatory rate		●	●	●		●	1			●		●					●	●		●		
b. Apnea	●	●				●	●	●		●			●	●			●	●			●	●
5. Inspired Gas																						
a. High/low FiO2								●		●								●		●	●	●

* Power source for generating breath; electricity is usually required for control system.
1 Requires optional monitor.
2 Pressure waveform adjustable as a function of pressure and flow settings.

these devices fit my criteria for a volume-controller. In my original paper, one criterion was that the delivered volume had to be measured directly by displacement of a piston. However, during the AARC Consensus Conference on Mechanical Ventilators, Dr Tom East pointed out that a more general criterion (and more correct from the standpoint of control theory) is that the ventilator use a volume signal to control the volume waveform; so, I revised my criteria for volume-controllers.[2] Thus, a piston-driven ventilator qualifies as a volume-controller because it maintains a consistent volume waveform, it measures volume as the stroke of the piston, and the piston rod and linkage provide a simple and elegant feedback mechanism. Any other ventilator that acquires a volume signal (for instance by integrating a flow signal) and uses it for control potentially qualifies as a volume-controller. For example, the Sechrist 2200B measures pulses sent to a stepper motor that drives a piston. Each pulse represents an incremental volume delivered to the patient circuit, qualifying the ventilator as a volume-controller.

I do not believe as Blanch and Desautels suggest that "Without using a body box . . . it is virtually impossible to volumetrically measure a quantity of gas serving as a patient's tidal volume." On the contrary, a calibrated super syringe is often used to precisely measure inspired volume to determine static compliance.[3] All bedside pulmonary function devices and metabolic carts measure tidal volume using a pneumotachometer, not a plethysmograph. A volume-controlled ventilator is an approximation to these devices. The principle is the same, only the level of accuracy is different because of the impedance of the patient circuit. The effects of the patient circuit on the accuracy of a ventilator's delivery device were fully described in my original article.[1]

Blanch and Desautels state that time-controllers ". . . offer no clinical advantage and might even be dangerous." Every high frequency jet ventilator I have seen (except the Bunnell LifePulse, but including the Infrasonics 1010), all flow interrupters (eg, the Infrasonics HFV module on the InfantStar ventilator), and some high frequency oscillators are time-controllers by my definitions. There is a large body of clinical data spanning the last 15 years that shows there are clinical advantages to HFV. In the 14 years that I have been building and using high frequency jet ventilators, I have found them to be safer and more reliable than conventional ventilators, precisely because of their simplicity.

So, the bottom line is that my system does make practical distinctions between four basic types of ventilators: pressure-controllers, volume-controllers, flow-controllers, and time-controllers. My system allows for discrimination based on input power source, drive mechanism, control scheme, and output waveforms, and each of these characteristics has several defined variations. Mushin distinguishes only between pressure-controllers and flow-controllers. Now, which system do *you* think is more specific?

I still maintain that the concept of "generated" pressure, P_G (in the sense of a driving pressure input to the flow-control device as Mushin used it[4]), is largely unnecessary if one focuses the classification scheme on the variables of the equation of motion. It may be useful in deciding whether classification criteria are met, such as Mushin's rule of thumb that driving pressure be 5 times peak airway pressure to ensure constant inspiratory flow, but further reference to it is not very helpful. Thus, if a ventilator is a volume- or flow-controller by the defined criteria, it is totally irrelevant whether the generated pressure is 100 cm H_2O or 1,875 H_2O. If the ventilator is acting as a pressure-controller, in many cases it is using a high generated pressure to deliver the high flow necessary to maintain the desired pressure limit. For example, the Bear 1000 has internal regulators to maintain air and oxygen generated pressure at 18 psi (about 1,265 cm H_2O), so *it has a high driving pressure regardless of whether it is acting as a flow-controller or a pressure-controller.* So, it is meaningless to refer to the generated pressure in the case of this and just about any other current model ICU ventilator designed to operate the same way.

It is true that the driving pressure of the Siemens 900C can be user adjusted (a rare feature), but setting the generated pressure too low in the volume-control mode simply makes the ventilator a poor volume-controller. Remember, a necessary criterion for being a volume-controller is that the volume waveform remains relatively unchanged as the load increases, *not* that a switch on the panel of the ventilator says "volume control." I provided explicit criteria for determining control variables and even expressed them as algorithms to avoid just this type of confusion. That such a situation could occur with a ventilator is the result of violating basic design rules[5] rather than a weakness of any classification system.

Blanch and Desautels mention that one reader was confused about pressure-controlled ventilation.[6,7] Piedalue correctly points out that it is ridiculous to say that pressure-controllers cannot provide PCV (pressure-controlled ventilation by my definition) and seems to have a good understanding of the new classification system. Blanch and Desautels make the same mistake as the original reader by saying that nonconstant pressure generators, by definition, are incapable of pressure-controlled ventilation. Earlier they made a big point of the fact that the terms "controller" and "generator" are synonymous. So, in their own terms, a nonconstant pressure "controller" is incapable of pressure-controlled ventilation, which is obviously self-contradictory. This is an example of how focusing on archetypal mechanical devices can lead to contradictory statements and confusion. They are confusing the concept of generated pressure (ie, the pressure drop across the ventilator's internal resistance and the patient's respiratory system resistance) with the concept of transrespiratory pressure (ie, the pressure drop across the patient's respiratory system alone). It is also a perfect example of how confusion is created by not defining your terms. Blanch and Desautels never define "PCV" in their letter, so references to constant pressure generators and time-cycling are bewildering. In contrast, by focusing on the equation of motion, I identified the key variables describing patient-machine interaction: *pressure* across the respiratory system, *volume*, and *flow* into the respiratory system. I defined pressure-controlled ventilation as meaning that the ventilator controls transrespiratory pressure to generate inspiratory volume and flow. If you want to explain the pressure waveform, then do so in a descriptive fashion using accepted mathematical terminology as I have outlined elsewhere.[1,2] The definition

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of a pressure-controller need have nothing to do with drive pressures, which might be high (eg, 5 times peak inspiratory pressure) or low depending on the ventilator design. Designations such as constant or nonconstant pressure generator are simplistic, confusing, and anachronistic because they are based on obsolete ventilator drive mechanisms (eg, bag-in-box systems driven by pistons and injectors).

One key point that Blanch and Desautels have overlooked is that a comprehensive classification system should describe not only the ventilator but also how the ventilator operates. Specifically, the system should organize and provide a framework for understanding ventilator modes. My system does this—Mushin's does not. Nor would we expect this from a book last updated 14 years ago. This may be one reason why Blanch and Desautels confuse pressure-controllers and PCV. Manufacturers have not attempted to standardize nomenclature and may even have added to our confusion by creating names that make their products seem unique, hence emphasizing differences rather than similarities. The individual trying to learn about ventilators is faced with a dilemma. The usual response is to try memorizing whatever manufacturers say about their products and to try not to think about the inconsistencies and contradictions. At the time of this writing, there are more than 20 different modes on different types of ventilators, with some individual ventilators offering as many as 9.

A more rational approach is based on the realization that any mode reduces to one of three general patterns of mandatory and spontaneous breaths: a pattern of all mandatory breaths, all spontaneous breaths, or some combination of the two based on conditional logic. These three groups can be further broken down to eight generic modes based on the control variable for mandatory breaths (ie, volume control, pressure control, or dual control). For simplicity, I will use the term "volume control" to signify that the inspiratory volume waveform is either directly controlled by the ventilator or indirectly controlled by controlling the flow waveform. *Dual control* means that both pressure and volume are monitored and used as control signals (however, at any particular moment during inspiration, either one or the other is being controlled, not both, as dictated by the equation of motion). With this system, we need only identify the type of conditional logic that switches between mandatory and spontaneous breaths to account for all current modes of ventilation (Table 2).

If you completely understand the generic modes shown in Table 2, then any term coined by a manufacturer can be easily fitted to your understanding rather than trying to adjust your understanding to an arbitrary description given in an operator's manual. Using this system, communication about modes is simplified and yet is more precise. An example of more precision is the following: Describing a mode as volume-controlled continuous mandatory ventilation is much more descriptive than saying assist/control. The latter term could just as well mean pressure-controlled continuous mandatory

Table 2. 'Generic' Ventilator Modes*

	Mandatory Breaths				Spontaneous Breaths			
Pattern	Control	Trigger	Limit	Cycle	Trigger	Limit	Cycle[1]	Conditional Logic Examples
CMV	VC[2]	pt/m[3]	flow[4]	volume/time	—	—	—	If sigh interval elapsed, increase tidal volume
	PC[5]	pt/m	pressure	time	—	—	—	—
	DC[6]	pt/m	pressure	time	—	—	—	If target expired V_T not met, increase pressure limit[7]
IMV	VC	pt/m	flow	volume/time	pt	pressure	flow	If pt effort in IMV window, synchronize breath (ie, SIMV) If target minute ventilation not met, increase rate (ie, MMV)[8]
	PC	pt/m	pressure	time	pt	pressure	flow	If pt effort in SIMV window, synchronize breath (ie, SIMV)
	DC	pt/m	flow	volume	pt	pressure	flow	If target inspired V_T not met, mandatory, else spontaneous[9]
CSV	PC	—	—	—	pt	pressure	flow	—
	DC	—	—	—	pt	pressure	flow	If target expired V_T not met, increase pressure limit[10]

---

* All current modes of ventilation can be uniquely described by one of eight basic patterns of mandatory and spontaneous breaths, modified with the appropriate conditional logic. CMV = continuous mandatory ventilation, IMV = intermittent mandatory ventilation, CSV = continuous spontaneous ventilation

[1] Flow-cycling may be replaced by pressure-cycling on some ventilators or may be patient-controlled (eg, continuous-flow CPAP systems) The most sophisticated systems deliver "pressure support" for spontaneous breaths as illustrated here Note that if the pressure support level (ie, the pressure limit) is set to zero, the breath is still pressure-limited to the baseline level.

[2] Volume-controlled (includes flow controllers for simplicity because flow and volume are inverse functions).

[3] Patient- (pt) or machine (m) triggered

[4] An inspiratory hold would create a volume limit.

[5] Pressure controlled

[6] Dual-controlled (ie, volume and pressure), either pressure is controlled within a breath and volume-controlled over several breaths (ie, Siemens 300), or the ventilation may switch between volume- and pressure-control within a breath (Bear 100 or Bird 8400 ST)

[7] Pressure-regulated volume control (Siemens 300)

[8] Mandatory minute ventilation, may also be accomplished by increasing spontaneous breath pressure limit instead of mandatory breath rate

[9] Pressure augment (Bear 1000) and volume assisted pressure support (Bird 8400ST)

[10] Presssure-regulated volume control (Siemens 300)

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ventilation (depending on the ventilator) and is also an ambiguous use of the terms assist and control, from a general engineering and physiology viewpoint. Any breath is assisted if the ventilator does work on the patient (ie, if airway pressure rises above baseline during inspiration[8]). To control means to regulate, and what is regulated if not the variables of the equation of motion for the respiratory system (ie, pressure, volume, flow, and time)? Saying control without specifying what is being controlled is meaningless.

Simplicity is served by realizing that synchronized intermittent mandatory ventilation (SIMV) is just IMV with conditional logic that looks at changes in baseline pressure or flow and a time window to synchronize flow delivery with patient effort; SIMV with pressure support is just SIMV with the spontaneous breath pressure limit set above baseline; mandatory minute ventilation is a form of SIMV with conditional logic that either increases the mandatory rate or the spontaneous assist level; pressure-controlled inverse ratio ventilation (PCIRV), airway pressure release ventilation (APRV), and BiPAP™ are similar forms of pressure-controlled SIMV.

New modes on the Siemens 300, the Bear 1000, and the Bird 8400ST are described in terms of dual control. The unique features of these dual control modes are illustrated in Figures 1 and 2. Using the Siemens 300, inspiration is always pressure controlled, with the pressure limit adjusted automatically by comparing actual and preset exhaled tidal volumes. The Bear 1000 is more complex in that inspiration may switch between pressure control and volume control (actually flow control) based on comparison of actual and preset inhaled volume. What makes things interesting and different from previous modes is that you cannot always tell beforehand whether the breath will be mandatory or spontaneous; it depends on what the patient does.

In the final analysis, it makes little difference what I think or what Blanch and Desautels think about classification systems. Students, educators, and clinicians will ultimately choose what is useful and discard what is not. They have already made such choices. I have received overwhelmingly positive feedback from representatives of all three groups. The only resistance has come from a few experienced speakers who seem unwilling to change their presentations. The new classification system has been adopted in the following textbooks.

Blumer JL. Pediatric Intensive Care. St Louis: CV Mosby, 1990.

Pierson DJ. Foundations of Respiratory Care. New York: Churchill Livingstone, 1992.

Pilbeam SP. Mechanical Ventilation: Physiological and Clinical Applications, 2nd ed. St Louis: CV Mosby, 1992.

Boynton B, Carlo WA, Jobe A. New Therapies for Neonatal Respiratory Failure: A Physiologic Approach. New York: Cambridge University Press (in press).

Tobin MJ, ed. Principles and Practice of Mechanical Ventilation. New York: McGraw-Hill, 1994.

Barnes TA. Core Text in Respiratory Care, 2nd ed. Chicago: Mosby-Year Book, 1994.

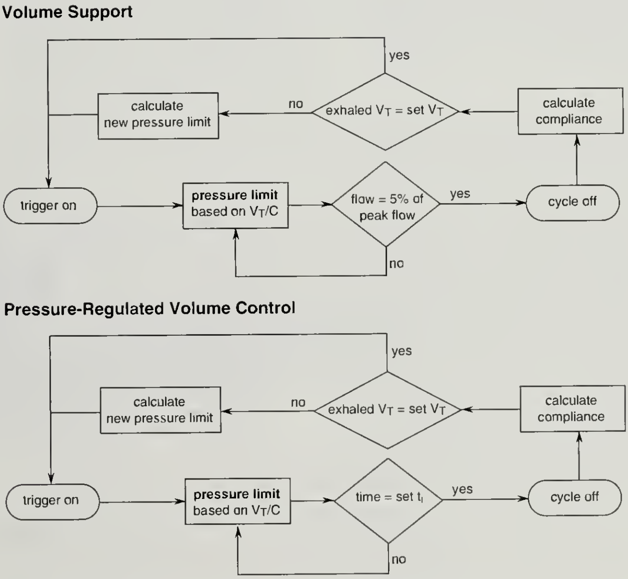
Scanlan C. Egan's Fundamentals of Respiratory Care, 6th ed. Chicago: Mosby-Year Book (in press).

White G. Equipment Theory for Respiratory Care, 2nd ed. New York: Delmar (in press).

Branson RD, Hess D, Chatburn RL. Respiratory Care Equipment. Philadelphia: JB Lippincott (in press).

Chatburn RL, Lough MD. Handbook of Respiratory Care, 2nd ed. Chicago: Mosby-Year Book, 1990.

These writers are leaders in the field, are shaping the belief systems of new generations of students, and have found the new system to be more useful. I call upon readers, especially students and educators, to comment. Let's open a long overdue dialogue on this subject. Are you


Volume Support

Pressure-Regulated Volume Control

yes
calculate new pressure limit
no
exhaled V_T = set V_T
calculate compliance
trigger on
pressure limit based on V_T/C
flow = 5% of peak flow
yes
cycle off
no
yes
calculate new pressure limit
no
exhaled V_T = set V_T
calculate compliance
trigger on
pressure limit based on V_T/C
time = set t_i
yes
cycle off
no

Fig. 1. Simplified algorithm describing two forms of dual control IMV found on the Siemens 300 ventilator called Volume Support and Pressure-Regulated Volume Control.

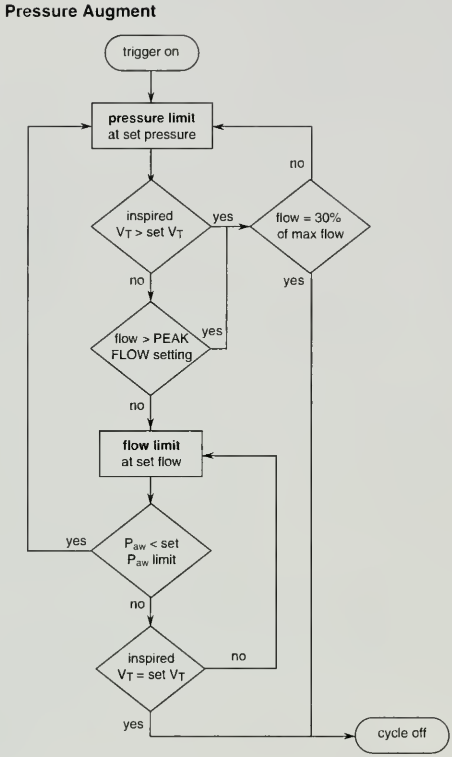

Pressure Augment

Fig. 2. Simplified algorithm describing a form of dual control IMV found on the Bear 1000 ventilator called Pressure Augment.

content with the terminology and concepts presented in ventilator operator's manuals? Do you like the new system accepted by your professional society at the Consensus Conference on Mechanical Ventilators? Do you have better ideas? What do you want from manufacturers along these lines? If you don't speak out you will have to settle for what is given to you, good or bad. As Thomas Jefferson said, "Error of opinion may be tolerated where reason is left free to combat it."

I'm disappointed and a bit surprised by the tone of Blanch and Desautels's letter. Where were they 3 years ago when the system was first introduced? Why didn't they participate in or comment after the AARC Consensus Conference in 1992? The health-care industry is changing rapidly, and I believe that for our profession to survive we must be willing to discard old paradigms. I close with the quote I used in my original article:

> *If you make people think they are thinking, they will love you. But if you really make them think, they will hate you.*
>
> *Blaise Pascal*

Robert L Chatburn RRT
Director
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Rainbow Babies and Childrens Hospital
Cleveland, Ohio

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An Educator Calls for a Standardization of Terms: Taking the Fat Out of Respiratory Care's Alphabet Soup

As respiratory care practitioners, we all know the "alphabet soup"[1-3] that exists for health care in general and respiratory care in particular. As I was teaching one of our program's Spring courses "Prolonged Artificial Ventilation" and during our Summer ventilator laboratories, it struck me once again how confusing the terms, acronyms, and abbreviations can be—confusing to the point of being ridiculous. Even well-defined and complete explanations in professionally prepared material[4] can be confusing and, perhaps, amusing—particularly to the person with little background in the field's jargon. To illustrate, I compiled the following.

Airway Pressure Therapy & Alphabet Soup

First came IPPB, CPPB, C, A/C, ZEEP,
NEEP, PEEP, and sPEEP. Then IMV,

SIMV, CPAP, NPPV, HFPPV, HFJV, HFO, IPV, VDR, and HBO. Eventually we got to CMV, AMV, EMMV, MMV, PSV, PCV, PCIRV, APRV, CDAP, PRVC, VS, ECMO, IVOX, and TGI. Coming at us is PAV, PLV, FLV, and NO.

RCPs and MDs are familiar with both PVS and FVS, which are forms of MAV. Now comes BiPAP™ S/T-D with APM and DCP where you may observe OFL on the LED. You may use S, ST, or T using BiPAP, CPAP, IPAP, or EPAP. The LED on the DCP will display BPM, OFL, and TV.

When using T, you must adjust % IPAP time for an acceptable I:E, IPAP, EPAP, and BPM, but make sure you turn on the APM first. When initiating or weaning you may increase or decrease IPAP and/or EPAP by 2 centimeters at a time. In emergencies you must do all of the above ASAP to augment FRC in order to raise S_{aO_2} and P_{aO_2} while lowering P_{aCO_2}, thereby stabilizing pH. Monitoring of HR, BP, RR, and EKG is also recommended. Perhaps all of this will culminate in a lowering of the WOB_I, as seen on the P/V loop.

All of this can be reviewed by looking at a VHS from the AARC on VCRs attached to TVs. Maybe someday soon someone will put all of this on CD-ROM and incorporate it into CAI and VR!

Remember that BiPAP™ S/T-D may also be used PRN, OK?

On a more serious note, I see a great need for the standardization of much of the field's jargon, particularly that related to mechanical ventilation. Students—and practitioners as well—can have their minds 'boggled' by the proliferation of terms. I believe that Rob Chatburn's 1991 article in RESPIRATORY CARE[5] (further developed in the Essentials of Mechanical Ventilators Consensus issue[6]) was as lucid as a presentation could be on how standard terminology can be used to explain ventilator function.

When will we get to the point where everyone uses the same terms to explain the function of the ventilators that we use? Perhaps this is still too much of a rhetorical question at this time, but I see the need for consensus on this issue—consensus more all encompassing and more complete than that expressed in the Association's Consensus Statement on the Essentials of Mechanical Ventilators.[7]

Will the Journal take the initiative to forge such consensus in the near future? I believe that it is time for such a conference and that RESPIRATORY CARE is the logical change agent.

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Notices

Notices of competitions, scholarships, fellowships, examination dates, new educational programs, and the like will be listed here free of charge. Items for the Notices section must reach the Journal 60 days before the desired month of publication (January 1 for the March issue, February 1 for the April issue, etc). Include all pertinent information and mail notices to RESPIRATORY CARE Notices Dept, 11030 Ables Lane, Dallas TX 75229-4593.

Lambda Beta Scholarships

The Lambda Beta Society, National Honor Society for the Profession of Respiratory Care, is awarding four $500 scholarships. An applicant should be a current student in or recent graduate of a school with an established Lambda Beta chapter. Criteria for selection are (1) evidence of scholarship (most recent transcript); (2) two letters of recommendation; (3) a sample of the applicant's written work (research paper *or* essay relative to respiratory care *or* an essay entitled What It Means To Be a Respiratory Care Professional). Deadline for submission is September 15, 1994. Scholarship applications are available from the school's chapter chairman.

Establishing a Lambda Beta Chapter

For information on establishing a chapter of the Lambda Beta Society, National Honor Society for the Profession of Respiratory Care, in your school, write, call, or fax the National Office of Lambda Beta Society, 1701 W Euless Blvd, Suite 300, Euless TX 76040 (pho 817-283-2835; fax 817-354-8519).

Grants Available

The Administration on Aging (Dept of Health & Human Services) announces availability of funds and request for applications under the Administration's Discretionary Funds Program for research, demonstration, training, development, and related capacity-building activities. Technical Assistance Workshops for prospective grant applicants are being held in several cities to provide guidance and technical assistance. Please call the appropriate contact person for the time and location in your city of interest: Washington DC, Alfred Duncker/Saadia Greenberg, Albert Byrd/Irma Tetzloff (202) 619-0441; Boston MA, Thomas Hooker (617) 565-1158; New York NY, Judith Rackmill (212) 264-2976; Philadelphia PA, Paul E Ertel Jr (215) 596-6891; Atlanta GA, Franklin Nicholson (404) 331-5900; Chicago IL, Eli Lipschultz (312) 353-3141; Dallas TX, John Diaz (214) 767-2971; Kansas City MO, Larry Brewster (816) 374-6015; Denver CO, Percy Devine (303) 844-2951; San Francisco CA, Frank Cardenas (415) 556-6003; and Seattle WA, Chisato Kawabori (206) 553-5341.

1994 Publication Awards

See page 677 of the June 1994 issue of RESPIRATORY CARE for information on the American Respiratory Care Foundation Publication Awards for 1994.

THE NATIONAL BOARD FOR RESPIRATORY CARE—1994 Examination and Fee Schedule

	Examination Date	Application Deadline
CRTT:	July 16	May 1
	November 12	September 1
RRT:	December 3	August 1
RPFT:	December 3	September 1

Fee Schedule

Entry Level CRTT—new applicant:	$ 90.00
Entry level CRTT—reapplicant:	$ 60.00
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Written Registry Only—new applicant:	$ 90.00
Written Registry Only—reapplicant:	$ 60.00

Clinical Simulation Only—new & reapplicant	$100.00
Entry Level CPFT—new applicant:	$100.00
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Advanced RPFT—new applicant:	$150.00
Advanced RPFT—reapplicant:	$130.00

	Active	Inactive
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RRT Recredentialing:		
Written Registry Examination	$25.00	$ 60.00
Clinical Simulation Examination	$65.00	$100.00
CPFT Recredentialing:	$25.00	$ 80.00
RPFT Recredentialing:	$25.00	$130.00
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Calendar of Events

AARC & AFFILIATES

July 26 AARC Videoconference. The AARC, in conjunction with VHA Satellite Network, presents the fourth of a 6-part videoconference series "Professor's Rounds in Respiratory Care: Arterial Blood Gas Troubleshooting: Interpretation, Analysis, and Quality Control" (1 CRCE credit). For information call (214) 830-0061.

August 3-5 in Orange Beach, Alabama. The Alabama, Louisiana, and Mississippi Societies for Respiratory Care present the 23rd Annual Meeting of the TriState Respiratory Care Conference at the Perdido Beach Resort. Presentations include "Care of Surgical ARDS"; "The Impact of Health Care Reform on Respiratory Therapists and How to Deal With It"; "Professionalism: Excellence in Presentations and Media Skills"; and "New Advances in Ventilator Technology." Participants can earn up to 10 CRCE credit hours. Contact Rocco Tretola BS CRTT, TriState Respiratory Care Conference, 6558 Orleans Ave, New Orleans LA 70124. (504) 482-3530.

August 3–5 in Albuquerque, New Mexico. The NMSRC hosts its annual summer convention at the Albuquerque Convention Center. Health care reform, differential diagnosis, altitude sickness, an asthma update, management roles and techniques, and the expanded role of the RRT in ACLS are featured topics. Activities include the annual golf tournament, Sputum Bowl, and a Las Vegas casino night. Contact the NMSRC at PO Box 35417 Station D, Albuquerque NM 87176-5417.

August 17-19 in Atlantic Beach, North Carolina. The NCSRC hosts its 16th Annual Symposium, "Clinical Technology: Accessing Our Future," at the Sheraton Resort. Contact Beverly Dukes (704) 342-6795 or Debby Harlan (704) 379-5889.

September 13 AARC Videoconference. The AARC, in conjunction with VHA Satellite Network, presents the fifth of a 6-part videoconference series: "Professor's Rounds in Respiratory Care: Hospital Operational Restructuring and Respiratory Care" (1 CRCE credit). For information call (214) 830-0061.

September 14–16 in Ocean City, Maryland. The Maryland/District of Columbia Society of Respiratory Care presents the 13th Annual Conference by the Sea, at the Carousel Hotel. The symposium highlights reengineering, benchmarking, and therapist-driven protocols. Contact Elgloria Harrison, RRT, at (703) 497-2500, or Sharyon Brown CRTT at (202) 884-3125.

September 22-23 in Napa, California. Chapter 10 of the CSRC, the American Lung Association of the Redwood Empire, and the Respiratory Therapy Program at Napa Valley College present the 12th Annual Napa Valley Conference, "Current Concepts in Cardiopulmonary Care." Contact Kate Benscoter at (707) 253-3145.

September 27–28 in Honolulu, Hawaii. The HSRC announces its 21st Annual Respiratory Care Conference at the Hilton Hawaiian Village Hotel. Contact Helen Ono RRT, 1717 Palolo Ave, Honolulu HI 96816. (808) 547-9532, fax (808) 547-9535.

OTHER MEETINGS

July 29–30 in Seattle, Washington. Voicing! presents the first of a series of 2-day programs entitled "Communication Approaches for Tracheostomized and Ventilator Dependent Patients," Harborview Medical Center. Topics include anatomy and physiology of tracheostomy, mechanical ventilation, communication options, assessment and treatment, dysphagia management, and clinical research. The $375 registration fee includes textbook, conference manual, refreshments, and luncheons. Other program dates include Aug 19-20 in Chapel Hill NC; Sept 16-17 in Louisville KY; Oct 7-8 in Houston TX; and Oct 21-22 in New York NY. Contact Voicing! at 3857 Birch, Suite 194, Newport Beach CA 92660. (714) 833-2710.

August 31-September 3 in Christchurch, New Zealand. The Third Congress of the Asia Pacific Association for Respiratory Care presents "Breathing into 2001," at the Christchurch Town Hall. Contact Stephanie K Humphries, The Planit Group Limited, Event Organizers, 201 Cambridge Terrace, Christchurch, New Zealand. (643) 366-5955, fax (643) 366-5944.

September 26–27 in Ann Arbor, Michigan. The University of Michigan Medical School sponsors "Update on Pulmonary and Critical Care Medicine" at the University's Towsley Center. The course focuses on interstitial and inflammatory lung disorders, evolving technologies, and recent concepts in pulmonary medicine, critical care, and infectious diseases. Approved for 14 hours of AMA Category 1 credit of the American Medical Association's Physicians Recognition Award program. Write to Registrar, Towsley Center for Continuing Medical Education, Department of Postgraduate Medicine and Health Care Professions, University of Michigan Medical School, PO Box 1157, Ann Arbor MI 48106-1157.

Sept 29-Oct 2 in London, Ontario, Canada. The Respiratory Therapy Society of Ontario (RTSO) presents its 22nd Annual Education Forum at the Radisson Hotel. Contact the RTSO Head Office, 122 Cumberland St, Suite 200, Toronto, Ontario, Canada M5R 1A6. (800) 267-2687.

March 12-15, 1995 in Denver, Colorado. The AARC and the National Jewish Center for Immunology and Respiratory Medicine announce the 5th International Conference on Pulmonary Rehabilitation and Home Ventilation at the Hyatt Regency Hotel. Postgraduate workshops on pulmonary rehabilitation, home ventilator care, sleep disorders, smoking cessation, and transtracheal oxygen are offered before and after the conference. The deadline for receipt of abstracts for poster/oral presentations on original research and clinical observations is November 1, 1994. Contact the National Jewish Office of Professional Education at (303) 398-1000.

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I. Type of Instn/Practice
1 ☐ Hosp ≥ 500 or more beds
2. ☐ Hosp 300 to 499 beds
3. ☐ Hosp 200 to 299 beds
4. ☐ Hosp 100 to 199 beds
5 ☐ Hosp <100 or less bed
6. ☐ Skilled Nursing Facility
7. ☐ Home Care Practica
8. ☐ School
II. Department
A. ☐ Respiratory Therapy
B. ☐ Cardiopulmonary
C. ☐ Anesthesia Service
D. ☐ Emergency Dept
III. Specialty
1. ☐ Clinical Practice
2. ☐ Perinatal Pediatrics
3. ☐ Critical Care
4. ☐ Clinical Research
5. ☐ Pulmonery Function Lab
6. ☐ Home Care/Rehab
7. ☐ Education
8. ☐ Management
IV. Position
A. ☐ Dept Head
B. ☐ Chief Therapist
C. ☐ Supervisor
D. ☐ Staff Technician
E ☐ Staff Therapist
F ☐ Educator
G. ☐ Medical Director
H. ☐ Anesthesiologist
I. ☐ Pulmonologist
J. ☐ Other MD
K ☐ Nurse
V. Are you a member of the AARC
1 ☐ Yes 2 ☐ No

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I. ☐ Pulmonologist
J ☐ Other MD
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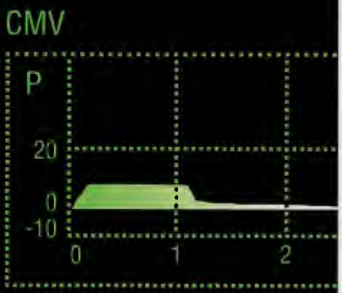

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